UNIVERSAL
LIBRARY

THE FOUNDATIONS OF INDIAN AGRICULTURE

(Formerly The Bases of Agricultural Practice and Economics in the United Provinces, India).

BY

H. MARTIN LEAKE, M.A., Sc.D., F.L.S.

Director of Agriculture, United Provinces, and formerly
Economic Botanist to Government United Provinces.

With a Foreword by

J. MACKENNA, C.I.E., I.C.S.

Agricultural Adviser to the Government of India.

SECOND EDITION

CAMBRIDGE

W. HEFFER & SONS LTD.

1923

CONTENTS

CONTENTS

PART IV

THE DEVELOPMENT OF AGRICULTURAL PRACTICE

PART V

THE DEVELOPMENT OF AGRICULTURAL ECONOMICS.

PART I

THE ORIGIN OF AGRICULTURE

CHAPTER I

THE FIELD COVERED BY AGRICULTURE

THERE are a number of features of the country-side which are to such an extent matters of daily observation and of daily experience that they have come to be accepted as matters of fact which deserve no further consideration. It is even possible that the amount of thought that that expression implies is not expended on them. Nevertheless, these features are worthy of a moment's consideration, for they carry the secrets of some of the fundamental problems of all agriculture, on a full understanding of which only is the practical agriculturist able to avoid losses and the reformer saved from championing impractical schemes of agricultural development.

Those of us who live in the country have simply to call to mind the commonest features of the country-side round our homes to obtain an impression which includes some of these essential facts. That impression will be somewhat of this nature. Surrounding the village is the cultivated land divided into fields. According to the season of the year our impression of the fields will be different. If our impression is formed in September or October it will be of some fields filled with crops, such as jowar, cotton, or sugar-cane, of others lying bare or fallow, and of still others in which there are labourers ploughing with their cattle or performing other forms of manual labour. A few months later, about February, the aspect will be entirely changed. The number of fallow fields will be few, and the main impression will be of waving corn fields and other cold weather crops. Later, in May, the aspect again changes, and the main impression becomes one of parched and bare fields. If our observation is carried over a second or, better still, over

a series of years, and for many of us who were brought up in the country this is the experience of our youth, we notice these changes of aspect recur in the same order at the respective seasons. While, however, the prospect, as a whole, is built up of the same crops succeeding each other in the same general proportions, if our attention is concentrated on a particular field, we will see that this general conclusion is not applicable to the individual units of cultivation—the fields—for the field that is carrying wheat one year will not carry wheat the next. The above impression may be recorded as two facts, as has been said, so perpetually under our observation that we fail to notice them or to appreciate their significance. They are these; there is a regular succession of agricultural procedure based upon the seasons, and that procedure, though similar in the mass, is diverse in the unit.

Let us glance for a moment at this diversity and see on what it depends. The cultivator decides what crop he will sow in any particular field, and it is on him, therefore, that this diversity ultimately depends. We shall get a clearer understanding, therefore, if we ask him why he adopts particular procedure. The answer will depend in some degree on his intelligence; it may consist merely of the statement that it is the correct thing to do; or it may contain a reference to the previous crop, that wheat will not do after cotton; or to the soil, that the particular soil is not suited to wheat. Both answers lead us to the same point; if we ask the less intelligent cultivator why it is the correct procedure he will be unable to answer you; if we ask the more intelligent one why wheat will not do after cotton, he, again, will probably be unable to give an answer. Pressure, in the form of the further question as to whether he has ever tried to grow wheat after cotton, will probably elicit the answer that he has not done so; his knowledge is based on what he has been told—in other words, he is basing his practice not on his own experience, but on that of others. These others are those who lived and cultivated the land before him. In the particular instance it is improbable that the father of the cultivator whom we have asked actually tried to grow wheat

after cotton ; he, in his turn, learnt it from his father. And when we use the word learn, we must be clear that we understand what is meant. It is not that the father in so many words conveyed this, and the thousand and one other facts of like nature, to his son. The son gradually grows up in his home surroundings, and in doing so gradually takes greater and greater share in his father's business, and so, largely unconsciously, comes to recognise certain limitations to what he may try.

Agricultural practice is thus largely an experience, to a very great degree unconsciously passed on from father to son, from generation to generation ; but an experience of what ? As our earlier remarks have stated, largely of the seasons and the relation of the crops to these ; but, as we shall see later, of many other matters as well. We have, also, described this process as an unconscious recognition by the son of the limitations on what he may try. This correctly describes the position of the actual cultivator. Within the limitations provided by the experience of his ancestors, and handed down to him, he is gradually building up an experience of his own. In most cases this personal experience is unconsciously built up ; but, none the less, the life of the cultivator constitutes the making of one long series of trials—of failures or of successes —and thus the building up of a personal experience added to that handed down to him. That personal experience may be small or may be great, its extent will depend on the intelligence of the individual cultivator, but, great or small, it exists. We have here the clue to the regularity we have observed in agricultural procedure as a whole. That procedure, as we observe it now, is the result of the accumulation of the centuries of experiment, of trials, of errors, or successes, and the regularity exhibited is a measure of the extent to which such experiment has standarised the procedure, leaving less and less scope for further experiment. Nevertheless, one essential feature stands out, agricultural procedure is an evolved one, and one which will continue to be evolved as the result of the accumulation of personal experience. The agriculture of to-day is not the agriculture of yesterday, or of to-morrow, and we

will only achieve full success in agriculture if we recognise this fact and remain always on the alert to make the most of our personal experience.

We may thus look upon agriculture, as we see it practiced around us, as the outcome of a system of trial and error; the parent adopts a particular practice, finds the return is less than that derived from an alternative practice, and, in future, adopts only the latter, which is accepted by the son as the standard system. Trial may, however, be of two kinds; it may be haphazard, or it may be directed. Present-day agriculture is largely built on trials of the former type. The cultivator does not grow wheat after cotton because experience, as accumulated from his ancestors, has shown it to be unprofitable; he will not be able to tell you why, and we must suppose someone once made the attempt. Trials of the latter type require a more complete knowledge. Modern science may be able to provide an answer to the question as to why wheat will not grow well after cotton, which our cultivator has been unable to answer. By providing answers to this and similar questions it will furnish suggestions for further trials with a view to making the cultivation of wheat after cotton possible; and these trials, if successful, might lead to the general introduction of the practice. Such a trial is a directed one. Present-day agriculture, in so far as it exhibits the regularity we have noticed, is the climax of the haphazard trial; further progress will be largely the result of directed trial. We must clearly understand, however, that these two processes are essentially the same, and that what we are concerned with is mainly a question of degree. The cultivator can tell you that he cannot raise a wheat crop after cotton, but cannot tell you why; we may, in terms of the chemical constituents of the soil and of its physical condition, be able to provide the reason, but we would find it very difficult to explain the difference between the wheat and the barley plant which makes the cultivation of the latter possible where the cultivation of the former is impossible. We have merely carried the point at which we are confronted with a question we cannot answer

a stage further. But, to the extent that we have consequently gained in knowledge, to that extent will we have at our disposal grounds for making directed trials. Progress in agricultural procedure will thus in future be largely dependent on trial of this nature, and consequently on the extended knowledge of the secrets of nature.

We have now considered one set of facts underlying the essential conditions of agriculture, and we can pass to a brief consideration of a second series which arise in like manner from our first impressions of the country-side. Among those impressions we have already referred to the fact that the cultivated area is divided into fields. Small and inconspicuous though the lines of division may be, their existence is of great significance. Probably everyone, and certainly everyone brought up in the country, knows that it is not sufficient, if we desire to practice agriculture, to purchase the necessary implements, to enter a bare field and to begin to cultivate it. We should not have progressed far before our proceedings would be interfered with ; we would find that someone was in existence who laid a claim to the land ; and, if we persisted in our action, we would soon obtain experience, through a court of law and an action for trespass, that that claim was one we could not afford to disregard. Before we can practice agriculture we must obtain a claim to the possession of an area of land such as that possessed by him whose land we have just attempted to possess. The existence of such claims to the ownership of land are so well known that the supposition we have made to illustrate it is almost superfluous. Nevertheless, this constitutes another of those essential facts on which so much depends that it is worth while spending a little time on their consideration.

We have seen that we can take possession of no land without meeting claims to ownership which we cannot ignore ; and, if we desire to obtain possession, we must proceed to discover someone who holds such claims, but who is prepared to part with them. This we shall find many ready to do if we are prepared to offer them sufficient in exchange. The arrangement may be of one of two forms ; either we may take possession

of the land for a limited time—one, two, or more, years—after which it will again pass into the possession of the previous owner; or we may purchase it outright, in which case the present owner relinquishes all claim to the land for the future. In the latter case, for permanent possession, we have, naturally, to offer more than in the former for temporary possession.

Several considerations arise from the above. In the first place we see that, before we can enter into possession, we must purchase land from a previous owner, and the inquiring mind will naturally ask how that previous owner established his claim to possession. Again, his claim is a definite one supported, if disputed, by legal documents and by a court of law. The origin of such claims, and the organisation which renders the possessor secure in his possession, are matters we shall have to consider in greater detail later. At present another aspect is more important. We must assume that our object in desiring to acquire land and to cultivate it is to earn a livelihood by doing so. That is the position of the vast majority of the cultivators of these provinces. The essential features are best brought out by considering the case where we rent for one year a certain area of cultivated land. For this we will have to pay a certain sum, and it is clearly not a business proposition if the value of the crops we raise during the year is insufficient to pay that sum. Nor will it be a business proposition if their value is only sufficient to pay that sum. We have expended labour on raising the crop, and we have had to live, to buy food and clothes, during the year. The value of the crops produced must be sufficient at least to cover the rent and the cost of food and clothing if our object in acquiring the land is to be achieved. Most people desire something more than this, and desire that, when they have paid off all essential expenses, there may be a little over for the purchase of what we may term for the present luxuries, or to put by for a rainy day. The argument is exactly the same if we buy the land outright, only the account is not balanced in a single year, and the essential features consequently are not so readily realised.

What are the essential features of these facts? They are these: for agriculture to be productive, and we are only concerned with agriculture of this type, it is not merely a question of production of a good crop, but of the production of that crop under conditions which will leave a balance when the expenses incidental to its production, rent, cost of food, of the clothing of the producer and of the implements used in cultivation, have been paid off. There are, as we shall see, many aspects to this side of our study which we may term the economic side. One such aspect is illustrated by what we have already said about purchase of land. It is not only necessary to find someone willing to part with the land he possesses, but willing to part with it at a price which will represent only a fraction of the value of the crops we can raise on it. A simple illustration of a second aspect is given by the study of yields. Practically it may be possible to raise the yield of a crop by one quarter, in the case of wheat, for instance, from 16 maunds to 20 maunds per acre, but if to produce that increase it is necessary to expend in, say, the purchase of manure a greater sum than those 4 extra maunds are worth, it is obviously better to raise 16 maunds than 20 maunds.

The fact it is necessary for us to appreciate is that there are two distinct branches of agriculture, one practical, the other economic, of equal importance and both fundamental. No one who is unable to raise good crops can ever succeed in earning his livelihood from agriculture, but it is equally essential to understand that the capacity to raise good crops does not necessarily imply success as an agriculturist. It is quite possible, of two men, equally skilful at raising crops, for one to earn a comfortable living while the other fails to do so completely. The one appreciates the economic aspect while the other does not. We shall have to devote, therefore, a considerable amount of attention to the economic aspect in the course of our study. And, just as the practical side was seen to be one of evolution, so is the economic side dependent on changing conditions. The economic conditions of to-day are not those of yesterday, nor those of to-morrow. Agriculture is thus essentially a subject of change—it cannot be

learnt as a lesson—it is the study of a lifetime to the man who would be successful, and we cannot here do more than develop the main principles, leaving success to be the outcome of subsequent personal experience. But inasmuch as the process is a gradual one, of which the nature will be the same in the future as in the past, it will help us too in our study if we commence by following that development from its origin, as far as we can trace it, up to the present day.

CHAPTER II

MAN'S DEPENDENCE ON VEGETATION

To appreciate the real significance of agriculture, and to understand its development, it is necessary to revert to some fundamental and elementary facts. The cultivator and those whose connection with the land is close are, it is true, from that intimate association nearer the appreciation of these facts than the inhabitant of the city. Though few of these former, even, themselves produce their entire needs, they are in a position to appreciate their ultimate dependence on plants, while the city-bred man too frequently does not look beyond the shop where he is accustomed to purchase his needs and overlooks the dependence of the shopkeeper on the agriculturist for the replenishment of his stock. It will help us in the beginning to study the cause of this dependence on plants.

Living organisms are of two kinds, animal and vegetable, the essential difference between which lies in the method by which they obtain that which is necessary for them to perform the function which constitutes life—growth. This necessity is what is commonly termed food. The process of life consists in building up, by the absorption of food, the body of the organism : the consequence of death is the destruction of that body. The tissues of the living body are mainly composed of organic matter, and their destruction is a process of reconversion of this organic, to inorganic, matter. The decay that we see when a plant dies and rots as it lies exposed to the weather, and the decay that we see when a dead animal is buried with the ultimate result that a few bones only remain, are essentially the same process as the destruction we see when wood, the product of the living organism, is burned in the fire—a process of the conversion of organic, to inorganic, matter. There is, thus, a constant destruction of organic matter proceeding, and there must, therefore, be a corresponding

construction also in process, or life would cease to exist. This is not the place to prove how this constructive process takes place; we may merely indicate that it is limited to the second class of organisms we have named, vegetable. Animals, in the ultimate resort, are dependent on plants for their food supply; in the ultimate resort, because we know of animals, such as dogs, tigers, and others, which are carnivorous or flesh-eaters. When we investigate these cases, however, we see that they are exceptions in appearance only. It is true these eat the flesh of other animals, but those other animals must feed on plants, as the food of the tiger is the grass-eating deer; or the process may be still more indirect, as when the panther kills a dog, which is itself a flesh-eating animal; but ultimately, at the bottom of the series, will be found a vegetable-consuming animal.

This is the first fundamental fact that we have to take into consideration, and the conclusion that it is essential for us to recognise in this respect is that man, so considered, differs in no way from other animals; he is absolutely dependent for his food, directly in the case of vegetarians, indirectly in the case of flesh-eaters, on the plant world. We have to consider in what way man differs from other animals; we can think of many, such as the wearing of clothes or the capacity for kindling fire, but these are not essential differences. Let us look at the life of an animal such as the buck. It has no home, and it wanders over the country-side, visiting first this field, then that; wherever it finds the most delicate crop, such as young wheat, there it will go to satisfy its hunger. When there are no such crops, as in the hot weather, it is compelled to fall back on the dried-up grass of the uncultivated maidans. Or consider the domesticated bullock; it has not the intelligence to search out the places where suitable fodder grows; it is driven by the youths of the village, or it has its food placed before it. What is the common feature of these two examples? It is this: the animal goes in search of its food; it neither raises it nor stores it, when abundant, against the day when there will be little. It is this feature that constitutes the essential distinction between man and other

animals. Man, instead of searching for the plants which provide him with his food, has learned to raise them in definite places. He has learned the function of the seed, and, by collecting this and planting it, he is freed from the need of spending his life searching for his daily food. He knows where he has sown the seed, and where, in due course, he will reap his harvest. By a further step he has discovered how to store that harvest so that the food that he raises at one season will be available throughout the coming season. By a further process he has forced animals into his service, to provide him with food or to help in its production. This is the essential difference between man and the animals, and it is, in other words, the essential feature of what is known as agriculture. It is a process of the subjugation of nature to satisfy the wants of man, and the history of agriculture is the history of the development of man.

There is a second fundamental fact that we must now consider. It is the extraordinary capacity of all living organisms to increase in number. Among animals we all must have noticed the apparently sudden increase in the number of mosquitos which takes place at certain times of the year, or in the number of other flies that appear in a similar manner. We are all aware also of the rapidity with which a weed like the Bainsurai (Pluchea) will spread over certain tracts where the conditions apparently suit it. But such observations do not give us a full appreciation of the capacity for self-multiplication possessed by most organisms. Thus a conger eel, commonly found in the sea around England, produces some 15 million ($1\frac{1}{2}$ crores) eggs. A wheat plant developed from a single grain will yield about 200 grains. A single shisham tree will produce during the course of a single season many thousands of seeds, and in a lifetime the number must run into millions. Such statements, however, do not, perhaps, bring out the full meaning of this capacity for multiplication, and we may express the facts in another way. If each of the 15,000,000 eggs of the conger eel were to develop and in their turn to reproduce, in two years' time "the sea would be a wriggling mass of fish." Even more

astonishing is the fact that a single individual of an organism known as Stylonichia—in itself so small as to be invisible to the naked eye—would produce in the course of a month a mass of living matter weighing some 200,000,000,000,000,000,000, 000,000,000,000,000,000,000,000 pounds—or a mass the volume of which would be a million times larger than the volume of the sun! Among plants we have stated that a wheat plant will yield some 200 grains. The produce of a single acre, therefore, would require some 1,600,000,000 acres in the fourth year for its cultivation!

Such examples could be multiplied indefinitely. The figures given are, perhaps, too large for us to grasp their full significance, yet, if we do so, we cannot but be struck by the contrast between them and the reality. We may notice a large increase in the number of mosquitoes at a particular time, but, if we carry our observation a little further, we will find the number decreases again instead of increasing. The sea is still composed largely of water, and the number of fish it contains does not visibly increase; the number of shisham trees remains practically constant. We cannot here follow to their ultimate conclusions the arguments which can be drawn between what might be and what actually occurs. The most obvious of the deductions that can be drawn is sufficient for our purpose, and that is this; of the 15 million eggs laid by the conger eel, 14,999,998 must, on the average, perish, and 2 only reach maturity. We have given no definite figure to the number of seeds produced by the shisham tree, but if we place it at the low figure of a million, 999,999 of these must on the average perish, one only growing into a tree. We are thus brought face to face with an enormous and universal mortality.

This leads us to the consideration of the cause of this mortality. We may consider a special case put in very simple terms. The tiger, as we have said, lives on the deer of the forest, and a sudden increase of their number would lead to a reduction in the number of deer until ultimately there must arise competition among the tigers for the remaining deer; it is conceivable that this competition would ultimately lead to the extinction of the deer, but this is not what actually occurs.

The reduction in numbers means increased difficulty in killing, and, in practice, extinction does not occur, but a balance is reached, and, for a particular tract, the relation between the number of tiger and deer is constant. Were this not so, the tiger would be responsible for the destruction of its own food supply, and therefore, ultimately, for its own destruction. We have thus arrived at the explanation of the apparent discrepancy between actuality and possibility. It is the limitation of the food supply that renders the possible million-fold increase impracticable. To realise that the same conclusion holds good with plants we have only to clear a small area of ground and keep it moist and open for a few days. If we then count the number of seedlings that have appeared on that area we will find that they number, perhaps, many hundred times the number of plants that could possibly arrive at maturity on that area. If we do not pull these seedlings up to count them we will be able to know the number which actually arrive to maturity and to ascertain the number that have died. The death of these is due to the absence of sufficient food for their growth.

Man, as we have seen, is an organism and an animal, and, as such, is subject to the same laws. He, too, multiplies; and, though the rate of increase is low when compared with the cases we have considered, it is probably larger than most of us have ever contemplated. "Man has doubled his numbers in 25 years." At "the same rate there would, in 1000 years, not be standing room on the surface of the earth for his offspring." He, too, is faced with the same limitations as other animals—the food supply. It is, perhaps, difficult for us to appreciate this when we are accustomed to obtain all our needs merely by going to the neighbouring bazaar. Nevertheless, it is a fact; and though he has, by learning to raise food instead of continuing to search for it, removed the immediate pressure, food still remains the factor limiting the rate of increase of man. Such a fact may not be obvious in peace time, but we cannot read the history of the recent war without seeing how all the activities of man, and ultimately his numbers, are controlled by questions of food

We have thus arrived by an entirely different route, at the point that we reached in the last lecture. By means of the organisation that he has built up, man has been able to remove the question of food supply from one of immediate concern to the individual who is thus able to reside or travel as he pleases with small limitation from consideration of the food question. He has, by that organisation, rendered it possible for him to associate in numbers far above those which the food supply of the neighbourhood can support. The cultivator is no longer concerned with providing the needs of himself and family, he has to study the needs of, and to provide the food for, these larger associations. There is thus a pressure on the cultivator stimulating him to produce more than sufficient to satisfy his own requirements ; the pressure, in other words, of the economic conditions under which man now lives to develop to the maximum the potentialities of practical agriculture.

These are the same two aspects at which we arrived previously, though we have started from an entirely different series of facts, namely, the practical, arising from man's discovery that it is easier to raise this food in definite localities than to search for it, and the economic, arising from the pressure produced by his capacity for multiplication interacting with the supply of food. These two aspects are intimately connected, and the history of agriculture is the history of the human race and its endeavours to raise an adequate food supply

CHAPTER III

THE DAWN OF AGRICULTURE

THE cause of development of the human race has been shown to be the outcome of man's efforts to produce a food supply adequate to meet the needs of his rapidly increasing numbers. Our object now is to trace this development, which extends back to the time when man differed but little from the highest animals. The earlier stages of such development have to be searched for long before the earliest written records, and the evidence has to be gathered in other ways. The fragments of information so collected can be built up into a continuous story, of which the main outlines are sufficiently clear. Such evidence is derived mainly from two sources. Just as the main course of evolution of the animal kingdom is traceable from the remains found in the rocks combined with the living forms now existing, so the evolution of man can similarly be built up from the remains of man and of his works and from the different stages in development found in the different living races. What the evidence from such sources shows the history of man in general outline to have been we can proceed to consider.

There is little doubt that the statement that, in his earliest stage, man differed but little from the higher animals is correct. Like the beasts, he was dependent on wild produce ; the social instinct was developed, but, like the animals, the limitation of the food supply prevented the association of a larger number than the parents and children. Associated with the end of this stage must have been the discovery of fire. Agriculture as such does not exist at this time.

The passage from this stage to the next is marked by the first development of agriculture, the clearing of land to plant a crop. This development is, however, very elementary. Land is only roughly cleared, the natural growth being frequently removed by fire ; the seed is sown in the virgin

soil with practically no cultivation and the crop reaped. We have here the first and most elementary attempts to control the food supply. Sufficient knowledge of the relation between the plant and climate has been gained to identify the sowing time. The wandering habit, which the necessity for searching for food rendered inevitable, is still retained, and as soon as the crop is reaped, the site of the cleared area, the crude field, is left and a new site is cleared for the next season. The development has, however, produced one important change. Though the crop is small relatively to the area "cultivated," if we can use the word in this connection, land is readily cleared and present in abundance. The social instinct is capable of further development; the accessibility of an increased food supply makes it possible for groups of individuals larger than the family to live in one place. Thus we get the social unit which we may call the tribe and the stage that of the wandering tribes. During the season when the crop is in the ground the tribe is unable to travel far, but once the harvest is past the tribe is free to wander till the next season. Associated with this stage is probably the first development of the domestication of animals.

The limit to the size of the community is still the food supply. Seasons, as we know, are irregular, and not infrequently a partial or complete failure of the necessary rains may occur. Under such circumstances the effect on a large community means a shortage of food which may even lead to actual starvation before the following harvest. Food is only produced in sufficient quantity to carry over a supply from one harvest to another, and economic development has not proceeded far enough to render any outside supply available when the local supply fails. The check to the numerical increase of the tribe is thus a severe one, and severer in proportion to the scarcity of bad seasons. The safe limit to which such a community can increase is that which the minimum food supply, that is the supply produced during the least favourable season, can support. Frequent bad seasons supply a constant pressure, checking the continuous tendency towards increase. Man is, at best, a careless creature, with little thought for the

morrow. The effect of a long series of favourable seasons will cause the tribe to increase up to the limits of the food provided by such seasons. When the bad season now comes the severity of the check is directly proportional to the extent to which the tribe has increased during the years of prosperity; proportional, that is, to the frequency of such years. We have here the fundamental facts of famine developed in their simplest form. It is a subject we shall have to consider in greater detail later.

The other point that we must notice in connection with this stage of development is that there is no lack of cultivable land. For the mere trouble of clearing the virgin growth sufficient land can be obtained to produce the amount of food required. Any increased demand for food can be met by clearing more land, and there is, consequently, no incentive to attempt to increase the outturn of the cultivated area; in other words, there is no stimulus towards the evolution of an improved system of agriculture. Methods are, therefore, still primitive.

Among the least advanced communities of the present day, and even in India, tribes but little advanced beyond this primitive stage are still to be found. We have called this the wandering tribe stage, but we must not, therefore, confuse these tribes with the wandering tribes we know in the United Provinces. For the conditions we are considering to exist, areas of jungle tracts unclaimed by any person, through which the tribe can wander and in which it can clear spaces at will, are necessary. Such conditions are rapidly disappearing in all countries, and have long vanished in the United Provinces, of which the wandering tribes are associations of vagrants deriving their living from the civilisation of others around them. In India the tribes of Madras known as the Chenchus, perhaps more nearly approach those whose conditions we are considering. Until the danger arising from the forest fires used by these tribes in clearing the jungle for their purposes caused Government a few years ago to control their movements and actions, they were accustomed to wander about the forests of that Presidency in a manner very similar to that we have described.

The third stage in the development we are tracing is

marked by the loss of the wandering habit. Instead of having no fixed place of abode the tribe settles down in one place, and substitutes the temporary dwelling places by one of a more permanent nature and creates a permanent clearance in the surrounding wild. Though, in the main features, there appears to be, perhaps, little progress, nevertheless this stage does show an advance in several directions over that previously described. We have a settlement established in the midst of wild, unowned surroundings. It is still dependent on its own resources for the supply of the necessary food, and hence the food supply still remains the primary factor in limiting the size of the settlement. Also, being surrounded by unowned and uncultivated jungle, there is no pressure on the land; any increase in population can be met, within limits, by clearing more of the waste lands, and any reduction in fertility consequent on repeated cultivation is met by such clearing of virgin lands to take the place of the exhausted fields allowed to pass out of cultivation. These conditions vary in the above respects but little from those we have described before; beyond a more thorough clearing of the natural vegetation, which the permanence of the settlement makes desirable, there is no incentive to an intenser form of cultivation than previously. The limit to the size of the settlement will be, through the food supply, the area cleared. It is, of course, possible to clear an indefinite area, but in practice there are limits which are fairly quickly reached at which it becomes more advantageous for some of the members of the settlement to migrate and to establish a new settlement with its own clearing in a neighbouring part of the jungle. Such considerations, as the distance of the fields from the settlements and the consequent difficulty of protecting the crops when they are more remote, are sufficient to keep the settlement small and encourage the development of subsidiary settlements.

The important difference between these stages thus lie not in the actual visible development in any particular direction so much as in the origination of those conditions which form the fundamental features of all subsequent progress of the human race. Foremost among these is the primitive conception

of land ownership. The tribe settles down and clears a space in the primæval wild for its home. In time it comes to look upon this possession as a right, an attitude which is proved by the resistance that would be offered to anyone who attempts to enter into possession. Around the cleared area is a tract, indefinite in extent, over which the settlers exert a claim, ill defined, but one which would be defended against all aggressors. That is, there has arisen an entirely new, but, as we have said, at present primitive, idea of land ownership. A second development arises from what we have said about the method of origin of new settlements ; the tribe is no longer the largest conception of social development ; the rudiments of a new, and higher, form have made their appearance. The mutual association is indeed slight, and is based on a common origin, but the development contains the germ of that idea of race or nation in which the complex social conditions of modern times have their origin.

It is possible to find, at the present day, numerous examples of settlements which fulfil fairly closely the conditions we have just described. Even in India they are fairly numerous in the more inaccessible tracts, though at the present time there is practically no part to which food could not be conveyed from outside if need arises and which is, therefore, entirely self-dependent for supplies. Government have, too, intervened in the interests of the country as a whole, and there is not, therefore, the same freedom to establish new settlements and to make new clearances as we have supposed. Nevertheless, the conditions are reproduced with a fair degree of accuracy in Central India, in the wilder parts of which the Bhils and Gonds live in such settlements, or in the hill districts of the United Provinces where it is a common custom for the cultivator to make new fields on the hill side to replace old discarded ones as soon as they begin to show diminished fertility. Conditions more truly representing those described, in that there exists a racial sphere of influence within which the settlements are situated, though separated by large tracts of unowned jungle or waste, will be found if we look outside India and turn to Central Africa.

It is not our purpose, however, to enlarge on this aspect of the evolution of the human race more than is necessary to bring out the essential features of that evolution in as far as they explain the concurrent evolution of Agriculture. So far, in the stages we have discussed, there is little real agricultural development.

The reason is clear; Man has been content with the satisfaction of his more elementary wants. Provided he obtains sufficient food and the little he requires in the way of clothing, he has little incentive for further enterprise, and he obtains the wherewithal to satisfy these wants along the line of least trouble. As long as ample land is available, that line is in the direction of increased area rather than increased yield. The pressure leading to the development of improved systems of agriculture arises later, when the increased population makes it the simpler method to expend more labour on cultivation.

The study of these earlier stages will not, however, be fruitless, as it will help towards a fuller understanding of the subsequent developments, and will, at least, bring out in the clearest fashion the direct dependence of man on his food supply.

CHAPTER IV

LAND HUNGER AND CITY DEVELOPMENT

So far as we have proceeded in our consideration of social development, the increase of population has been accompanied by a corresponding increase in the area cultivated and by but little improvement in those methods of cultivation which will alone give an increased yield. The check that the food supply places on that increase is an intermittent one, its intensity, as we have seen, being inversely proportional to the frequency of its application. Judged by outward appearance, the next stage is marked by no great change in the method of life of people, and the clearest conception of it will be obtained by considering it as the logical outcome of the last.

The tendency, as has been seen, is for the size of the settlement to remain relatively small and for the increase in the population to be met by increase in the number of settlements. This development cannot, however, go on indefinitely. In the absence of any force retarding expansion, such as invasion by external enemies or the ravages of an epidemic disease, a time must come when the settlements, at first isolated, become confluent and the expanse of unclaimed jungle reduced to the vanishing point. There is, thus, a practically continuous expanse of cultivation with only such amount of waste land as is necessary for the supply of grazing for the cattle, for the supply of firewood, and for such like purposes. An increased food supply is now no longer obtainable by an increase of the area under cultivation ; exhausted lands can no longer be allowed to go out of cultivation in exchange for virgin soils, since no such soils remain. We have reached the time when the population must cease to multiply, or more must be obtained from the available land. The first of these alternatives is unthinkable ; it is against what we have seen to be one of the primary instincts of all living animals, and it is the

direct stimulus supplied by this instinct that is responsible for the subsequent development of agriculture, a development which leads to the production of an ever-increasing outturn from the fixed area available.

Free inter-communication is now possible between neighbouring settlements, or villages as we may now call them, and through these a crude system of intercourse, which may extend over a wide area, may be established. That intercourse does not, however, permit of easy transport of goods in any quantity; and since the weather is uniform throughout considerable tracts, and the crops in one village will be poor at the same time as they are poor in all the neighbouring villages, it is now the country-side, and not the individual village, that becomes self-supporting in the matter of food. Distances are too great to permit of the transport of food from the locality where production has been good to that where it has been poor, and the direct dependence of the population on the food supply is still readily recognised. The density of the population will thus depend on the climate, and not only on the climate, but even more so than before on the frequency of bad years.

To find conditions approximating to the above we must go far away from the influence of the roads and rails. Perhaps they are best illustrated in the submontane tracts bordering on the jungles of Bahraich and Gonda. Here the jungles have only recently given way to cultivation, and the land is all newly brought under the plough. There are no roads or rails to remove any excess production, which is practically limited to the supply of the local needs. Owing to the recent character of the clearing and to the favourable local conditions yields may be fairly high, but methods are crude, and the standard of implements and cattle low.

Two further points must be noticed before we pass on to the new stage. The first we shall have to consider in greater detail later; it is the organisation of village life. For the present it is sufficient if we notice that each village is self-contained, and that all its members are very closely dependent on agriculture. Certain of these, it is true, may not actually cultivate the land themselves, they may prepare the implements of cultivation,

or the few household necessities required by the actual cultivators and their families, but for their labour they are paid in grain. Payment is thus made in kind, and we are able to see that the true basis of exchange is the grain commonly used by the community.

The second is not in the same way practically demonstrable. As long as land is abundant and obtainable for the mere labour of clearing the desire to possess will be small. With, however, the decrease of the available land, a definite desire for possession must arise, and it will arise before there is any real shortage. All of us who have any experience of land are aware of the different degrees of fertility that occur even within short distances, and the first desire for definite possession would arise over those areas where the natural fertility results in a large return relatively to the labour expended in production. Such desire implies competition, and competition implies disputes which are settled either by the stronger taking possession or by reference to a third person. From this it is a stage, easy to be understood, to the establishment of some definite system for the settlement of such disputes. To follow this development further would lead us too far away from our subject ; it is sufficient to indicate here the way in which the claims to which we referred in the first lecture have come to be built up, and to show that, concurrently with the establishment of the claim, there must also have arisen a system for protecting the owner in his claim. That is the first indication of a form of Government into the various types of which we cannot proceed to enter further than to point out their origin within the community. They may therefore be termed communal.

With the increase in number of communities, each arising by a process of budding off from an older and larger community, it is not difficult to understand that the authority of the parent community would, for a time, retain a certain hold over the younger. But that that hold would be slight and would not, without some cohesive force, be of long duration, and that the rudimentary national ideas to which we have referred would be short lived, we cannot doubt. That cohesive force is found in the necessity for protection against

external enemies. Just as there is a sphere of influence around each settlement, and as these settlements increase in number, the spheres of neighbouring settlements become contiguous, leading to boundary questions between the various settlements, so, on a larger scale each race, or association of settlements having a common origin, has its larger sphere of influence, and these, in time, must have come into contact. Between such races there is no community of feeling, such as common origin gives between the settlements, to lead to an amicable settlement, and such questions are then settled by a resort to force. In that decision the race which has held together will obtain the victory, and the cohesive force of which we have spoken is supplied in this manner. It is represented by what we may term a racial or national Government, the form of which may be very diverse. We are not concerned with this diversity, a study of which would lead us into sociological questions. The essential point for us to distinguish is that the primitive function of Government is dual, consisting of internal administration and external defence. In the disturbed times through which most nations of the world have passed, force has commonly been appealed to and the defensive function of Government has at times figured as the main, if not the only, one. Nevertheless, internal administration constitutes an important, and from the point of view of our present study, the most important section of its duties.

If we have followed this account of the consequences arising from the two fundamental facts, the increase in the population and its limitation to the available food supply, we will see that they explain the necessity for an improved system of agriculture and the organisation of the social life under a system which may briefly be termed Government. Hitherto the population is, both individually and collectively, closely dependent on agriculture, and the highest form of communal life is that of the village. The next stage is marked by a radical change in the method of life of a part of the population. With the establishment of a Government arises a centre in which persons begin to congregate. To meet the needs of these persons, needs which become more and more complex

as time progresses, arises a class of providers, at first possibly retaining their connection with the land, but subsequently becoming completely independent and living entirely on the proceeds derived from the supply of the wants of others. At first these would be artisans, each producing and selling particular classes of goods, subsequently traders, bringing from outside goods which cannot be obtained locally, and, in addition, the providers of the food supplies required to feed this population. There thus arises a definite non-agricultural population primarily at the seat of the government, and subsequently, as trade develops, where better facilities occur for the production of any particular goods. It is again not our object to trace out the evolution of a city population except in so far as the origin of such a non-agricultural element affects agricultural development.

Clearly, this element requires to be fed, and, being unable to produce its own food, is dependent on the cultivators of the surrounding country, and there is thus an indirect pressure on the neighbourhood tending to the production of larger crops Each cultivator has now to produce more than that to which he has been accustomed, and more than he wants to satisfy his own personal needs, and his excess produce goes to supply the needs of those who do not directly produce food. We may have difficulty at present in understanding how this pressure on the individual cultivator to produce more is exerted. This will be more readily understood at a later period after some further study. For the present we will merely note the possibility of the original owner of the claim becoming one of the non-agricultural community, and, while retaining his claim, ceasing to cultivate himself and giving permission to someone else to cultivate it. Such a position develops conditions favourable for bargaining, and the price that the owner will obtain in return for the right to cultivate his property will depend on the number of persons desirous of possessing that right—a number continuously increasing. That price tends, therefore, to get higher and higher; it is represented by the payment of a portion of the produce to the owner. The actual cultivator is thus driven to produce over and above what he

requires to satisfy his own wants, sufficient to meet the demand of the owner. With such competition for actual possession of the limited land available becoming ever more intense the proportion of the crop which passes to the owner becomes ever greater, and if the cultivator is to supply his needs out of the remainder he must constantly strive to produce more.

Limitation to the size of such towns is still very definite, the population is dependent on the excess produce of the surrounding country, and the supplies are purely local, a fact which, as we have seen, limits the number of persons that can be supported to the food supply of the least favourable years. Nevertheless, this limitation is beginning to be less severe. The stimulus to production is ceasing to be the personal requirements of the cultivator, and is more and more becoming the necessity for paying the demand of the owner. That demand is regulated, not by what the owner requires for his own needs, but by what he can get as the result of competition for possession. He is, therefore, frequently in possession of far more than he himself requires, an amount which he may or may not desire to dispose of immediately. There arises thus an incentive to storage, and the produce of a good year is held over and used to relieve the stress of a bad year.

We have seen how a non-agricultural population has arisen which earns its means of livelihood by the manufacture of articles for which a demand has arisen. This population, too, requires to be fed. As long as the needs of the individual are few, as is the case in the village which is self-contained, the manufacturer of the household vessels, the maker of the cultivators, implements, and so on, is working for his fellow villagers, and can be paid for his labour in the produce of the field. This ceases to be the case in the town. The needs of the individual have become very diverse, and it is no longer possible to pay for goods in kind. If, for instance, we wanted a brass lotah and possessed a maund of wheat, we might meet many makers of lotahs such as we require, but one might want rice, another sugar, and so on, and all be unwilling to take our wheat. It would clearly be impossible to carry on much trade under such a system. It is at this stage, then, that the first

needs of some simpler method of payment developed, a need which has been met by a system of tokens. By their means we are enabled to take our maund of wheat to someone who is willing to take it and who will hand us its value in tokens which we can then take to the maker of lotahs, who will give us the lotah we require, and in his turn give these tokens in exchange for the sugar he requires. There has thus been established a system of tokens as a basis of exchange, and these tokens are what we now call money. In India this token is now the rupee, and to this rupee basis all goods are referred. It is important to understand that the value of the rupee is mainly as a token, convenient for handling and as a means of exchange. We can buy silver for our rupee, but it does not necessarily follow that the amount of silver we get will be the same as contained in the rupee. We need go no further into the question of coinage. Sufficient has been said to show that, with the origin of a non-agricultural population, arose the need for a means of making the exchange of goods simpler, and that that need has been met by what we know as money.

To discover localities where such conditions exist we have to turn to the somewhat densely populated tracts removed from roads and rail. The spread of the latter makes it harder each day to find such tracts, and it is probable that none exist where the external influence brought by road and rail is not in some degree felt. Nevertheless, we can probably all think of some place near our homes where the conditions approximate to those we have described, small townships or large villages with a few thousand inhabitants. From the very nature of the case they are small, relatively unimportant, and, consequently, probably unknown to a resident of the other end of the Province. It must be left, therefore, for each one of us to select, from our own knowledge, the place that appears to us most fully to satisfy these conditions.

Chapter V

THE INFLUENCE OF OPENING UP COMMUNICATIONS

We have now arrived at an advanced stage in the development of the community, and one that was typical of the larger proportion of the United Provinces till within a comparatively short time. Subsequent developments have been rapid, but have only been rendered possible by influences directly affecting the food supply. These developments may be summed up in the expression, improvement in transport facilities; in the first place, pucca roads; in the second, railways; and, lastly, in sea transport or ships.

We have seen how the last stage we have considered has accounted for the origin of small towns dependent on the surrounding country for its supplies. As long as no facilities for traffic exist beyond the kuchha road or the village footpath, the distance from which supplies can be drawn is limited by the difficulties and labour of carriage. Most townships have been content to remain in that state of development, but in certain cases, where special causes exist, such as facilities for making special articles, the trade in these articles will require, in the first place, a means of getting the goods to the markets; and, secondly, increased facilities for bringing the extra food required to support the expanding population which results from the expanding trade. In the simplest form these are supplied by pucca roads, which, by making cart traffic lighter and rendering it possible at all seasons, lead to an increase in the area from which supplies can be drawn. In countries which have been settled for a long time an intricate system of roads has been built up. This is the case in England, and a large portion of Western Europe where we find a network of such roads extending from one end of the country to the other.

In such countries the road system has been built up before the application of steam to the purposes of traction led to the development of railways. In countries of relatively recent economic development, in which condition we may place the

United Provinces and the alluvial tracts of Northern India in general, there was no general system of roads before railways made their appearance. The one main road of communication, the Grand Trunk Road, was originally designed as a military measure. Beyond this, pucca roads were only found radiating out from the larger cities and ended blindly in the district. There was thus no completed network of roads when railways were first introduced, and the tendency has been to connect up centres by rail. If we examine a road map of the United Provinces in which the pucca roads are marked, it will appear that a system of pucca roads connecting up the main centres was in course of development when the railways were introduced. With the building of the railways which, in general, follow the line of the roads, the process of road construction fell into abeyance, and such work as was undertaken was diverted from the original intention of building up a network of road communications to providing feeders to the railways. We thus find blind roads radiating out from railway centres, but forming no through communication which is provided by the railway. The main line of the Oudh and Rohilkhand Railway illustrates the change in plan very clearly. The general road line is clearly marked, but is only pucca in isolated sections; while at frequent intervals similarly isolated stretches of pucca road, radiating from various stations on the line, are examples of the later policy.

The effect of pucca roads alone does little more than enlarge the area from which food supplies can be drawn, and so increase the potential size of the town; they may also place the town within easier reach of the market for its main produce. But, at the best, road traffic is slow, and the area from which food supplies can come by road alone is constricted and insufficient in extent to include any great differences in climate. Any failure of the crops through unfavourable seasons will affect the source of food supply uniformly, and there is in this respect but little difference between this stage and the previous one, and that difference is mainly one of degree. Periods of scarcity will arise which will react on the population and prevent the development of really large cities. With the introduction of

railways, however, there is introduced a change which is more than one of degree. Food can now be transported from one side of India to the other with the same facility that it was before possible to carry it a few miles. Consequently a city population is no longer dependent on the local food supply. The area from which food is drawn now includes diverse climates, and is of such a size that failure of the food supply owing to a bad season occurring simultaneously throughout is, if not an impossibility, at least unknown. Any shortage in food supply in one locality, owing to unfavourable seasons resulting in bad harvests, is at once made good by the importation of supplies to make up the deficiency. There is, thus, no longer any restriction to the size of a city, the imposition of which is due to the food supply. Such restriction as does occur is imposed by the possibility of procuring employment, or the means of earning sufficient to buy the necessary food. This is too intricate a problem for us to enter into at present, and would lead us too far away from our main subject, though we shall have to consider it a little more deeply later. For the present it is sufficient for us to notice that there is now no essential restriction to the size of a city that is on the railway communication of the country.

The effect of the development of sea traffic is even more to broaden the basis of the source of food. With ready means of sea traffic countries even are no longer dependent on their own food production and may contain a far larger population than this will support. Such is the case in England, the population of which is many times larger than the local food supply can maintain.

Under normal conditions that ultimate dependence on the food supply is, as we have seen, not readily recognised, but that it is the ultimate factor to which all other factors are subordinate becomes apparent under abnormal conditions such as existed during the recent war. The threat to England through her food supply and the pressure brought to bear on Germany and her allies through their food supplies are sufficient to show that, though unseen, this question of food supply is always present.

The effect of this opening up of communications is largely economic, but reacts in many directions on agriculture. The increase in the size of cities offers a means of livelihood for the excess population of the agricultural districts from which there is a steady stream of persons to supply the labour that a city always employs. The development of cities is usually associated with the origin of industries which require raw material for their development, and that raw material is frequently of vegetable origin. Of such a nature is the development of Cawnpore with its cotton mills and of Calcutta with its jute mills. There frequently arises, thus, in cities a demand for industrial raw material as well as for food, a demand which is as important as the demand for food, for if the supply of raw material is cut off the mills must close down, the labour remain unemployed, and the means of purchasing food removed. The establishment of industrial centres in cities creates a demand for large supplies of agricultural produce which is not food.

Now one of the most important considerations in industrial enterprise is the cost of raw material, and the cost of raw material as well as of food depends on three main factors, cost of production, of collection, and of conveyance. Of these three the essential factor is, of course, conveyance ; since, without the power to convey the goods, the other two could not come into play at all ; but its cost is also important, for if it be large relative to the cost of producing the material, it would mean that the source of supply would have to be near the city. Were that so the introduction of rail and sea transport would have had little effect in altering the economic conditions ; it is not so much, therefore, the fact of its existence as the fact of its cheapness in relation to the remaining cost of the material, permitting the source of supply to be far removed from the centre of consumption, that is responsible for the development we have described. We must not, however, overlook the remaining factors, the cost of production and of collection, and trace their effect on agricultural development. Cost of production depends on, among other things, the price of land which, as we have seen, rises in densely populated areas owing

to competition for possession. It will be less, therefore, away from the centres of population, and in recent years large tracts previously uncultivated have been thrown open to cultivation. If we compare the map of the United Provinces to-day with that of only 50 years ago we will be surprised to see to what an extent the cultivated area has increased and the jungle diminished. Still more marked and more directly showing the relation between cost of production and cheap transport are the development of the canal colonies in the Punjab, which has been rendered possible by canal construction. If we go outside India we find examples of the same phenomenon in the enormous wheat expanses of Canada and America, of the Argentine, and of Australia. Cheap production and cheap transport have made possible the development of these areas, for they have made it possible to bring the material to the city at a cost which is not greater than the cost of the same material grown nearer at hand, while leaving a profit to the grower.

We have still the third factor to consider, the cost of collection. It is not hard to understand that if we want to procure 1000 maunds of wheat for sale it will cost us less if we are able, by going to one or two centres only, to obtain the amount we want than if we had to travel through fifty or a hundred villages purchasing a few maunds at each. It will be cheaper, even when we pay the same price for the wheat in each case, because, in the former, we can complete our purchase and arrange for its despatch probably in one day; while, in the latter, not only will it take us several days to go round the villages, but the conveyance of each separate purchase to a single centre will have to be arranged for before despatch can be effected. We have here an example of the advantage of handling material in bulk. Industrial development, and the development of large cities has raised a demand for materials—both raw material and food—in bulk and at a cheap price. It follows from what we have said that demand will be most cheaply met by production in bulk, for such production will reduce the cost of collection to a minimum. Practically this means that the development of city life and industries, as the result of cheap transport, reacts on agricultural development in

the direction of marking off of particular areas as the centres of production of particular crops. It further follows that proximity of the source of supply to the centre of consumption is a minor matter owing to the cheapness of modern methods of transport.

The factors which will decide what area will produce what crop will be various ; principally suitability of climate. That, however, will not be the only factor, others will also affect the ultimate decision. It would, for instance, be impossible to grow the poppy plant for opium production in countries where labour is dear. The collection of opium involves an enormous amount of labour, and the crop can only be raised where that labour is not only available, but available at a cheap rate. It is, for instance, inconceivable that it could be profitably grown in Australia, however suitable the climate might appear, for labour is only available at a rate in the neighbourhood of Rs. 7/8 per day.

The above remarks will, perhaps, be more readily comprehended if we look at a few instances of this localisation of crops in definite areas. The best example within the United Provinces is that of cotton, which is localised in the south-west corner of the province. The Muttra district has over 30 per cent. of its kharif area under cotton, and as we pass eastwards the percentage grows less and less until, in districts like Gorakhpur, it is practically non-existent. This distribution is very largely the result of climate, cotton preferring a drier climate than is found over most of the United Provinces, but it is also noticeable that the centre of the area of production is at a distance from the place of consumption, for, though mills are situated at Hathras, the nearest large manufacturing centre is Cawnpore.

If we look outside the United Provinces, and more especially if we look outside India, numerous instances of this localisation of crops will be found. Wheat is produced in large quantities in the Canal Colonies of the Punjab, and the prosperity of these colonies is dependent of the disposal of the excess wheat, which is transported to other parts of India, and even as far as England. It is on the price realised for this excess wheat that the

whole prosperity of the population and the power to purchase other necessaries depends.

Jute is another instance, being almost entirely produced in Bengal, and prosperity depends on the transport facilities available to carry the jute to Scotland. In recent years mills for working up jute have been established near Calcutta, and therefore near the source of the supply. This has been rendered possible by the development of the coal industry, which has brought cheap power to Calcutta.

Outside India instances of the same development are given by the cotton tracts of America, the wheat fields of Canada, the Argentine and Australia, sheep in Australia and New Zealand, and cattle in South America. In all these cases production is far in excess of local needs, and, not only so, but frequently, as in the case of cotton in America, production is of an industrial commodity at the expense of food. The population is dependent in such a case on this importation of food, and obtains the means to purchase this food by the disposal of the industrial commodity produced locally, a disposal which is dependent on a ready and cheap means of transport.

Chapter VI

THE FUTURE OF INDIAN AGRICULTURE

In previous chapters we have considered in very brief outline the manner in which agriculture has developed from a very primitive to the complex system we now see it. If we understand it aright, we will see that this development consists of two stages; one, comparatively slow, and covering centuries in which the governing factor has been the direct limitation of the population by the food supply; as long as the population is dependent on the local food supply progress cannot be rapid, though a very high standard of agriculture may be reached by the pressure on the land. Compared with this stage the second is very brief, and dates its origin from the application, less than a century ago, of steam power to the development of traction, from the time that is, of railways and ships. This development has resulted in the opening up of enormous areas of land, previously uncultivated, areas which produce infinitely more food than is necessary to meet present local needs. This development has been rapid, and is, in a sense, a return to the condition of the early settlements, where land is obtainable for the asking, and increase in production is obtained by the expansion of the area cultivated rather than by efforts to raise the yield of the cultivated area. Just as a time came when the settlements became confluent, and the pressure of hunger produced an advance in the system of cultivation, so a time will again come when a world's shortage of food will demand a universal improvement of this system.

Our study of the development of agriculture has led us back to what was said at the end of the first lecture, that that development is an evolution which is still in progress, and will continue to progress. It is only a clear appreciation of that fact which will prevent us from falling into the error of thinking that we can ever know all that is to be learned on the subject. We cannot, and never will be able to, attain that much-desired

condition because a new aspect is arising every day. Our success in whatever practical relation we are brought with Agriculture, whether as land-owners, as cultivators, as estate managers and so on will depend in large measure on our appreciation of this fact and on our consequent readiness to continue learning.

As we have shown by occasional references, India exhibits various stages of agricultural development from the very primitive methods of the Chenchus, to which reference has been made, to the highly advanced methods, the outcome of dense population, in the fertile alluvial plains of Northern India in one direction; and to the specialised methods, the result of ready transport, in the other. We have already referred to cotton, wheat and jute as instances of such specialisation. The spice and coffee gardens of Southern India; the tea gardens of Assam; and, till recently, the indigo industry of Bihar afford other instances.

Before we leave this section, which we may term the introductory section, of our subject, we may consider the present agricultural conditions in India a little more closely. As a whole the effects of modern development and recent introduction of transport facilities have only begun to be apparent. The changes wrought by such developments are much more apparent when they are wrought in new, and consequently flexible, surroundings. Where an old and intricate system has developed, progress is not nearly so rapid. Thus we find in the Punjab, tracts which, less than a generation ago were uninhabited, or with only scattered villages, now progressing under a more advanced system of agriculture than, perhaps, anywhere else in India. The population is dependent on the transport facilities for its prosperity, and agricultural development has been moulded by that dominating feature. The case of the Punjab is, however, exceptional. Throughout the rest of India, and especially in those portions where climate as well as soil has been kindly, as in the Gangetic delta and throughout most of the Gangetic plain, an intricate system—both practical and economic—of agriculture had arisen before the goods train and the cargo boat came to alter the face of

the earth. Here there is not the same flexibility as in the more recently opened tracts, and the change in conditions is much more gradual. We find here that the cultivator's first object is still to provide the food requirements of himself, his dependents and his cattle, and it is only when he has arranged for this that he turns his attention to the growth of crops with a view to disposal of the produce. Though the excess production of the area may be large in bulk, that bulk is made up of a very large number of individually small amounts, and, therefore, to the cost of production has to be added a comparatively large sum for collection. Economically, therefore, the system is unsuited to the modern conditions. Practically agricultural development in these tracts lies very largely in the direction of bringing the economic conditions of production as far as possible into line with modern needs.

From these stages we pass to the less developed tracts of India, where the pressure of population has not been sufficient to evolve any intense form of agriculture. Here methods are crude, production is on a small scale, and mainly directed to support the local population. And, finally, we come to the very rudimentary stage of agriculture represented by the wandering tribes.

India, as a whole, then, is a land showing very diverse and very varying degrees of agricultural development. Progress must be gradual; must be, that is, from the existing standards; and the methods will therefore vary with the local conditions. A considerable amount of local knowledge is consequently necessary. In backward tracts considerable progress may be at once made by the introduction of agricultural methods already common elsewhere. Such, for instance, is the transplanting of rice, which has produced such marked results in the Central Provinces. These methods are not available, however, in more advanced areas. The problem of progress here becomes much more complex. It is, for instance, easy to show that deep ploughing will improve the fertility of a field and lead to better yields, but deep ploughing involves larger and more expensive ploughs, stronger cattle, and, if unintelligently performed, may easily lead to poorer yields in the first

instance. This means greater expense in the purchase of cattle and implements, greater cost in feeding the cattle, and, possibly, a diminished immediate return. It is useless recommending such a process to a cultivator who is only producing enough to supply his immediate wants from season to season. He cannot afford the extra expense, and he cannot borrow the necessary money. Improvement in this case can only be effected by providing the means as well as the method; that is, by considering the economic, as well as the practical, aspect.

If we revert to what we learned earlier about the origin of the idea of land ownership and of the meaning of the term Government, we see that the tribal form of government has passed and large portions of India have passed under a settled form of Government. This unification of Government has led, if not to the removal of tribal feuds, at least to their settlement by peaceful means. Government in India still maintains its rôle as upholder of the peace and of defence against external enemies, but, while doing so, also maintains a very intricate and elaborate record of the ownership of the land. Throughout India, in the backward as well as in the more progressive tracts, it is no longer possible for an individual to take possession of land. If no individual owner exists, ownership is vested in Government from whom rights to possession have to be acquired. As we shall see when we come to discuss this subject more fully, the system under which land is held is very different in the different tracts of India, and the nature of these systems has a very great influence on Agricultural development.

If, again, we revert to what has been said of the origin of a demand for a means of exchange and the development of a system of tokens, to which the name money has been given, we will remember that demand originated when specialisation arose leading to an artisan class. The members of this class gradually lost any original connection with the land that they must have possessed, and were dependent for their food supply on the income derived by their labour in the production of objects which others desire to possess. With the increasing complexity of social conditions we saw that considerable

difficulty arose in the producer meeting one who possessed the food required by him, and who, at the same time, was willing to exchange this food for the article he, the producer, desired to part with. We saw how the establishment of a money system removed this difficulty and so facilitated trade. As long as we consider trade within a small locality this system is simple to understand. It is more complex, however, when we come to consider international trade—trade between countries. We may purchase, for instance, a thousand tons of wheat for despatch to England. For that wheat we have to pay the producer tokens in rupees, annas and pies, while the person to whom we despatch it receives in England tokens in the form of pounds, shillings and pence. Now the despatching of those pounds, shillings and pence in so much metal will not help to pay us for the wheat we have provided. Not only do we require rupees, annas and pies, but the transference of so much solid metal would be practically impossible. The development of cheap transport has led to the development of international exchange. We have despatched 1000 tons of wheat, and in payment for this require, say, a lakh in rupees. Our purchaser, instead of sending cash, which, as we have shown, would be useless, will find out a merchant who has despatched a lakh's worth of, let us suppose, cotton goods to India for sale here. He will now be able to pay the supplier of cotton goods with £6,666, the equivalent of 1 lakh of rupees, a transaction which is readily made as both parties are in England, and the supplier of cotton goods will arrange for the Indian purchaser to pay a lakh of rupees to us. In this way both the accounts are adjusted without any despatch of actual money from one country to the other.

By this means the actual transfer of the metal tokens is avoided, but this, of itself, would be of little advantage; international trade would be restricted if our purchaser in England of a lakh's worth of wheat had to search for a trader who had despatched £6,666 worth of goods to India. Just as the restriction on local trade is removed by the establishment of a token system called money, so, by an organisation known as the banking system, restriction to international trade is

removed. Under this system our purchaser will deposit £6,666 with the Bank in England, and will receive from the bank a "bill of exchange" of that value payable in India in our favour. This bill he sends to us as suppliers of the wheat, and, on presentation at the bank in India, we receive a lakh of rupees. The banks are in a position to do this, because the total amount of payments to be made one way differ but little from the total amount of payments the other; consequently, with the sums received in the English banks in settlement of debts incurred for purchases in India, these are able to pay the sums owed by purchasers in India for goods procured from England. Sufficient has been said for our present purpose on the subject of exchange to explain its main object, and we need follow it no further into the manner in which any balance is adjusted when the value of the trade one way exceeds the value of that in the reverse direction, into the way the banks repay themselves for their services and such like. We will only note further that a similar system is largely used for making payments within the same country, and even within the same city. Here the bill of exchange is represented by a cheque. If we in Cawnpore buy 100 maunds of wheat from a merchant in Lahore we can make payment by writing a cheque for 400/-. That cheque is an indication that we have paid the sum into the bank, whose name is on the cheque, and the Lahore merchant will receive 400/- when he presents that cheque to a bank in Lahore. Here again the bank receives and pays out money, so that only the balance of all transactions has to be adjusted by the actual transfer of cash.

These are all matters which it is not possible for us to go into in any detail at present. Some of them we will have to look into in further detail at a later stage of our studies. For the present it is only desirable that we should get some idea of the complexity of the subject, some idea of the extent to which agriculture is dependent on the economic system. If we have really understood this it will not be hard to understand the importance of a possession of a knowledge of that system. The possession of this knowledge will be seen to be still more important if we have followed and understood, what we have

repeatedly laid stress on, that this system is at the present time undergoing rapid change, that the time is a time of progress, and that the man who is going to make his way in agriculture and reap the largest reward is the one who understands these matters and is consequently able to anticipate their effects.

PART II.

THE BASIS OF AGRICULTURAL PRACTICE

CHAPTER VII

CULTIVATION AS IT AFFECTS THE PLANT

WE have already seen that the importance of plant cultivation, which is the central feature of agriculture, and to which all others are secondary, depends on the fundamental fact that plants alone are able to add to the total organic matter in the world. The truth of this statement is, perhaps, more readily realised in India, where the population is largely composed of vegetarians, than in other countries. We have now to look into the question of cultivation more closely and to see exactly what happens when the cultivator tills the soil and raises his crop. The cultivator takes the trouble to grow the crop for the sake of the particular produce it yields, and he naturally desires to obtain as much of that produce as possible ; within the limits of his knowledge and of his means he does all he can to attain this result.

The central dominating factor in this process is the plant, and the cultivators' efforts are directed to making the conditions of growth such as will cause the plant to produce the greatest amount of seed or the largest roots; in fact, the biggest return of whatever it is which forms the particular portion of the plant that has an economic value to man.

The cultivation of plants has been described as the collection of similar plants into one locality so as to render the act of gathering the produce easier. Not only does it do this, but it increases, as we shall see, the amount of the produce available for collection and use. Such a collection of similar plants is called a crop. The comparison of such a crop with the natural

growth of the jungle will help us to obtain a more detailed idea of what cultivation really implies. Natural growth is the outcome of the deposition of the seed of plants on the undisturbed surface of the earth, and, from what has been said already, we know that the number of seeds is far in excess of the number of plants that can grow and attain maturity. There thus arises competition between plants, a competition which is dual in its nature. On the one hand a particular plant will shed its seed round itself, and the number of those seeds will depend largely on the particular species, but will in any case be sufficient to yield more plants than the area in which they fall could support if all germinated. There is, thus, competition between individual plants of the same species. On the other hand, within the area on which the seed of this particular plant is scattered, there will already be plants of other species also shedding their seed. These, again, germinate, and there arises a second competition between plants of different species. Natural growth, as we see it in the jungle in the widest sense of any uncultivated space, is the result of this competition ; it is composed of the survivors, of those most fitted to the conditions. There is continually at work a process of natural selection leading to the survival of the fittest, and this selection is, on the one hand, between species and, on the other, between individuals of the same species. All living wild plants are the survivors of such competition applied through centuries, and it is not surprising, therefore, that, under most natural conditions, a large number of species have attained so nearly to the same degree of fitness that no single species survives to the exclusion of the remainder. Hence a jungle is usually a mixed one. Nevertheless cases do occur where a single species occupies an area almost to the exclusion of others. Examples of this are given by the sal jungles ; by the shisham jungles which occur, for instance, on the islands opposite Hardwar ; by the jhao jungles of the Ganges kadir and, to a lesser extent, by the almost pure stretches of wild indigo found here and there, especially on ravine lands, and by the stretches of kans grass and bainsurai found in lands allowed to go out of cultivation. In these cases the competition between species has

eliminated practically all but one dominant one; but, although it is no longer apparent, and there appears to be only competition between individuals of the same species, interspecific competition must still exist, for seed of other species will be constantly deposited within the area occupied by the particular plant in question and the plants developed therefrom, if germination takes place, must perish without attaining maturity.

Selection, then, in nature leads to the elimination of all but the hardiest species, and of these all but the hardiest individuals. Both these forms of selection are, however, removed or modified in the case of cultivated plants. A wild annual plant like the pyazi produces, let us say, 100 seeds, most of which are scattered over the area, a few square yards in extent, within which the parent plant grew. From what has been already said we will have no difficulty in understanding that, on the average, 99 of these 100 seeds will fail to develop into mature plants the following season. Of these 99 seeds, some will be eaten by birds, swept away by rain or wind, or carried away on the feet of men or of animals before germination; but the death of the remainder will be subsequent to germination and due to two causes, competition with other species and competition with the remainder of the individuals left from the original 100. Of these two, in a mixed jungle, competition with other species will be the more intense.

Let us look at this matter a little more closely, and, for the sake of simplicity, we will consider an annual plant which normally reproduces itself a hundred-fold. By limiting our consideration to an annual we will simplify the discussion while only affecting the argument to the extent that, in the case of an annual, a new individual is produced each year to replace the old one, while, in the case of a perennial, the number of new individuals is reduced to agree with the number of individuals which die in one year.

In the case of the pure jungle an area capable of supporting a certain number of plants will, at the time the seed ripens, receive 100 times the number of seeds that can arrive at maturity in the succeeding season. Only a small number of

these will survive to germinate, and of these all except one in each of the original 100 will attain maturity. It is not possible, however, to harvest on ripening a number equal to that of the failures to germinate. Whether the entire seed crop or only a portion of it is allowed to be shed naturally, a portion only in each case will fall into cracks or be covered by accidental disturbances of the earth. The seed not so protected will be carried away by wind or rain, by birds or ants. To appreciate how efficient such agencies of removal may be it is only necessary to scatter a handful of grain and watch the result; in twenty-four hours it will be difficult to find even a single grain. The long tracks so often seen radiating out from an ants' nest, perhaps 100 yards or more in length, and covered with a continuous stream of ants, each bearing a grass seed, indicate the same fact. It is, therefore, possible to remove only so much seed as will not materially reduce the number that survive till germination, and this will be a mere fraction of the total seed produced. It is difficult to estimate the exact proportion of the seed that might be so removed and thus rendered available for food for no such food-producing plants occur as natural pure jungles; but it is likely to be small in amount and insufficient to build up a reserve of any magnitude.

In a mixed jungle the question is more complicated. The seed produced in a given area will be much diminished, for the number of individuals yielding seed are relatively few. That small amount of seed, however, will be subjected to the same agents of removal before germination; while, after germination, competition with other species will be added to competition between individuals of the same species. The latter form of competition will, on the average, be less than in the case of the pure jungle, for the relatively few plants will scatter their seed unequally throughout the area. But that diminution in the intensity of the competition will be more than made up by interspecific competition, and the result will be, as in the case of the pure jungle, the development to maturity of a single plant to replace each plant of the preceding year. Under these conditions the amount of seed that can be removed to form a food supply will obviously be less than in the case of the pure

jungle. Experience shows that it is, in this case, insufficient to form any reserve supply, and is only sufficient to supply the immediate needs of a sparse nomad population.

When we turn to the crop we find that the conditions are entirely different. We may take a crop of wheat to illustrate the main considerations involved. In the first place all losses between harvest and sowing time are avoided, and the stock of seed available for food falls short of the entire stock produced only by so much as is necessary to raise a full crop on the area cultivated in the succeeding season. Again cultivation removes, or practically removes, the competition which arises between different species after germination and during growth. Such competition as exists, therefore, is limited to competition between individuals of the species which forms the crop. If we examine the wheat plants in a normal crop we will find that they develop on the average two to three ears each, and that each ear bears some forty grains. It will not be an excessive estimate, therefore, if we consider that a single grain of wheat yields 100 grains. Yet, with the common seed rate of one maund of grain to the acre, a yield of twenty maunds under ordinary conditions of cultivation would be considered good ; in other words, in practice one grain of wheat is found to produce twenty only, and it is necessary to sow five grains to obtain one mature plant. Some few of these grains are, no doubt, removed by birds or ants at once, and this source of loss is not entirely removed ; but the majority germinate only to die from one cause or another. It would be incorrect to assume that the whole of this loss is due to competition between individuals of the species composing the crop ; were this so a lighter sowing would yield an equal outturn, while we know that if we sow much less than one maund we will not get a full crop. Nevertheless, a considerable proportion of this loss is due to individual competition, and we are enabled to obtain some idea of its magnitude from the above figures. If we accept an outturn of twenty maunds, which is above the average for irrigated tracts in the United Provinces, we see that nineteen maunds, or ninety-five per cent. of the total yield, is available as food supply without diminishing the size of the succeeding crop.

Cultivation, thus, consists essentially of the removal of competition as the result of the clearance of the land and of sowing the seed of the desired crop in the area so cleared, while the amount of seed sown is sufficient to give a full crop. With the removal of that competition; with the removal, that is, of natural selection, disappear also the consequences of that selection which we have termed the survival of the fittest. It is no longer the hardiest plant that survives. In place of this we find a milder form of selection, or no selection at all, carried out by man.

What, for instance, does the ordinary cultivator usually do when he reaps his crop? He cuts the whole field, and, from the bulk of grain obtained by the process of threshing, sets aside sufficient to sow the area he requires in the following season. In this process there is no selection, and the only selection that obtains under such circumstances is that between the five seedlings for the space occupied by one. It is possible, however, to conceive of a selection carried out by man, and in fact such a selection is frequently carried out. If, before the crop is cut, the best plants are selected and the produce of these set aside for seed purposes; or even if, in cases where the seed forms the valuable portion of the crop, this seed is examined and the best of it set aside for seed purposes, and the remainder only disposed of, we have a definite form of selection. The basis of this selection, however, is now no longer fitness, in the sense in which we have used it, that is, hardiness and vigour leading to the survival of the possessors in the intense competition which occurs chiefly in the seedling stage; it is the capacity to produce either a large quantity or a more desirable quality, of that for which the plant is grown by man. It is usually a selection carried out on the mature plant, at a time, that is, when the plant has passed the stage at which competition, and hence selection in nature, is most intense. Not only, therefore, is natural competition and its consequent selection removed as the result of cultivation, but it is frequently replaced by a totally different form of selection based on competition acting at a different stage of the plant's life and on the purely arbitrary standards fixed by man. It is not surprising, therefore, that

cultivated plants as a whole have lost their hardiness and their capacity to develop under natural conditions.

In the competition that we have seen to go on in nature cultivated plants have little chance of surviving. Nor do they survive. If a handful of wheat, for instance, is thrown at harvest time on to any uncultivated stretch of land, it is probable that not a single plant will develop during the next season. This perhaps is not a fair example ; wheat is probably an imported plant, and, even in its most undeveloped form, incapable of surviving the hot weather and rains ; and the test with wheat would only be a fair one in a temperate climate. The maize or makkai, again an imported plant, would almost as certainly fail to develop ; while, in the case of cotton, though a few plants might develop in a stunted form, they would give little or no seed from which a second generation could develop. In one or, at most, two years after seed had been scattered, therefore, all trace of the cultivated plant would have disappeared. It is true intermediate stages are to be found ; the poppy plant, for instance, sheds naturally a good deal of seed, and this will germinate and grow the following year, even on the uncultivated divisions between the fields. The plants, however, instead of being two or more feet high, with large conspicuous flowers, are two or three inches high only, and will merely be observed when carefully searched for. It is possible that, in such cases, survival may last for two or three years, but even these will, in the end, be exterminated by the truly wild plants.

The method in which this artificial selection by man reacts on the plant is one into which we shall have to enter more fully. That it has been practiced in the past, largely in the same unguided manner as we have already seen general agricultural practice to have been built up, cannot be doubted. The difference which we know to exist between wild and cultivated plants is sufficient indication of its occurrence. The nature of that difference has been dealt with above ; its magnitude is such that in many cases it is impossible to identify any wild plant which may be considered as the stock from which the cultivated plant has been derived ; yet, if our

description of the origin of agriculture be correct, it follows that all cultivated plants are originally derived from some wild stock. The origin of cultivated plants forms a fascinating subject, but one into which we cannot enter here. That study will lead us, however, to the conclusion that all cultivated plants have been so derived at some more or less remote period, those that have been longest in cultivation differing to the most marked extent from any living wild plant.

CHAPTER VIII

THE PHYSICAL CONDITION OF THE SOIL

IN the last chapter we have dealt with the chief characteristics of cultivated plants. These may be summed up as a relative delicateness, or as a capacity for resisting adverse conditions, which is small in comparison to that of wild plants. To meet this delicateness of the cultivated plant the cultivator is compelled to control as far as possible the conditions under which the plant grows with the object of making them as favourable as possible. He will only be able to do this if he understands what the plant requires and in what way those requirements are derived by the plant from its surroundings.

The plant, unlike the animal, is stationary, and draws food for its growth from the inorganic world in which it lives and by which it is surrounded. This growth is in two directions—a downward one of the root into the soil, and an upward one of the stem into the air. From both sources it derives certain food-material essential for healthy development; from the soil, water and the mineral salts contained therein; from the air, the carbon which forms the basis of the organic matter, of which the greater part of the plant is built. Its relation to both is, thus, intimate, and the nature of both requires consideration and understanding.

The soil consists essentially of particles of solid matter of irregular shape and variable size. Owing to this irregularity, these particles do not fit into each other to form a solid block of mineral matter; the soil has a sponge-like structure in which are a series of cavities intercommunicating with each other, the size of the cavities and of the passages leading from one to the other depending on the shape and size of the individual particles. The soil, therefore, consists of two portions, the actual solid matter and interstitial space. It requires little thought to perceive that considerable importance

attaches to the relation between the volumes occupied by these two portions. This relation, then, requires a somewhat detailed consideration.

We may consider a cube the sides of which are all 2 metres in length. Its volume will be 8 cubic metres. Into a cube of this size we are able to fit a sphere of radius 1 metre, the volume of which is 41·88 cubic metres, or 52.36 per cent. of the volume of the cube. But we can replace this single sphere by 8 spheres, each having a radius of 0·5 metre, or by 1000

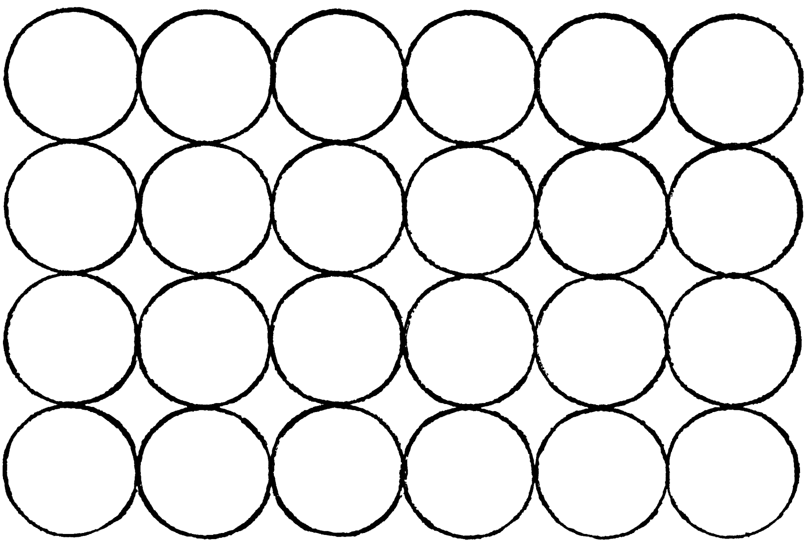


Fig. 1

spheres, each with a radius of 1 decimetre, or by 1,000,000 spheres, each having a radius of 1 centimetre; and we can thus build up the cube with which we started from a series of similar particles regularly arranged and approximating to the condition of the soil, in that the cube is now composed of two portions, solid matter and interstitial space. The volumes of the 8 spheres of ·5 metre radius, of the 1000 spheres of ·1 metre, of the 1,000,000 spheres of 1 cm., or of the 1,000,000,000 spheres of 1 mm. radius are, however, all identical, and equal the volume of the single sphere which we were able to fit into the original cube. Consequently the volume of the

interstitial space, when the particles are spherical, of equal size, and symmetrically arranged within the cube, is 100—52·36, or 47·64, per cent of the total volume. There is, however, more than one symmetrical arrangement of spherical particles having the same diameter. The one we have been considering is illustrated in Fig. 1. A second symmetrical arrangement in which the particles are more closely assembled and the

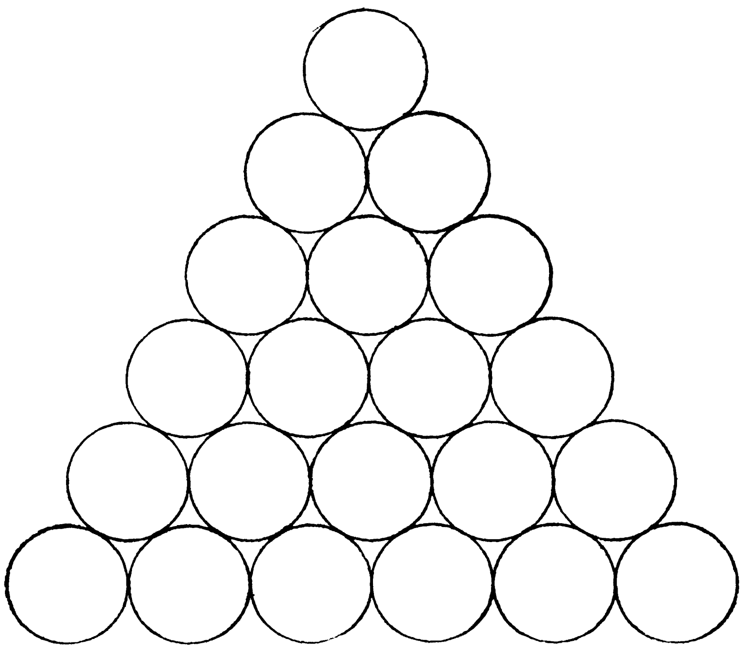


Fig 2

interstitial space is reduced in this case to 25·95 per cent. is shown on Fig. 2. As long as symmetry of arrangement and equality of size are maintained between the particles, the volume of the interstitial space will be one of these two figures, and independent of the actual size of the particle. But, as we know, or can readily see, such uniformity of size is not found in the particles of any soil. The effect of the lack of uniformity will be indicated by supposing that there be introduced into the more closely packed system of spheres just described a second set of spheres, of such a smaller size that they exactly fit into

the spaces between the larger ones (Fig. 3). In this system the interstitial space will become 6·76 per cent. of the total volume. The effect of irregularity of size is, thus, to reduce the volume of interstitial space, since the smaller particles are able to fit into the space between the larger ones ; and, were this the only factor influencing the interstitial space, we should find the volume of this space much lower than is usually the case

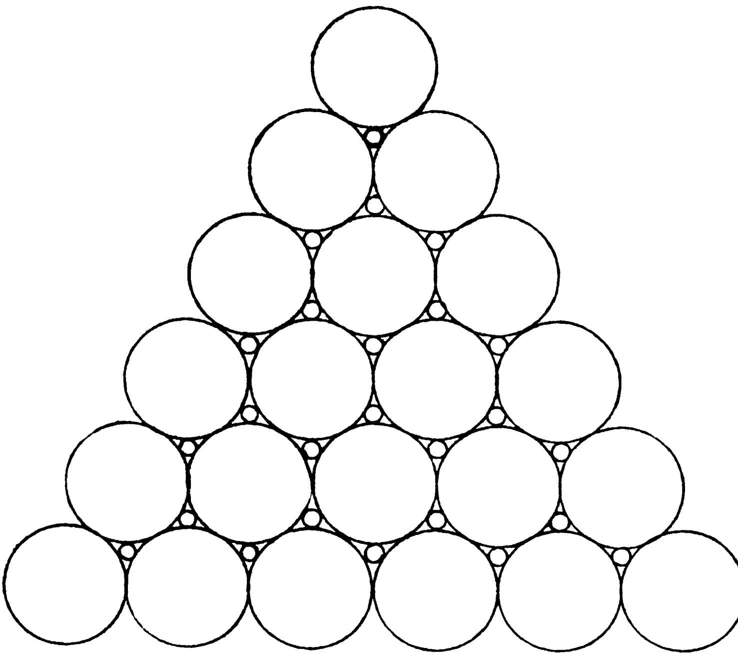


Fig 3

There are factors which counteract this effect, chief of which is the capacity of the soil particles to form aggregates. In most cases it will be found that the soil does not break down into its ultimate particles, but into small groups of a greater or less number of particles which only become separated by application of some force such as friction between the fingers. Under such circumstances the interstitial space is composed of two portions, the smaller spaces between the individual particles of an aggregate and those larger spaces between the individual aggregates.

We have so far assumed that the particles of which the soil is composed are solid, but this is not necessarily the case. Certain substances formed in the soil, such as limestone or organic remains, are porous. The effect of this condition is similar to the effect which would be obtained were we to replace the solid spheres in the case we have considered by spheres of sponge, namely, an increase in the interstitial space. The combined effect of these factors which influence the volume of the interstitial space, some of which, as we see, are in the direction of its reduction, while others lead to its increase, is to give an interstitial space of between slightly over 50 and 25 per cent. of the total volume. The former occurs in the so-called "heavy" clays consisting of aggregates of fine particles, whose individual weight is insufficient to overcome the friction of one surface on another, and which, consequently, do not settle into the position giving minimum interstitial space; the latter, in sand, the particles of which do not adhere to each other, and consequently readily settle down into this position.

If we revert to the example we have given above we see that in a cubic metre we can place either one sphere of a diameter of 1 metre, 1000 spheres of a diameter ·1 metre, 1,000,000 spheres of a diameter of 1 cm., 1,000,000,000 spheres of a diameter of 1 mm., and so on. The surface areas of these spheres will be 3·1416, 31·416, 314·16, and 3141·6 sq. metres respectively. In other words, the surface area of a solid mass of matter increases inversely to the diameter of the particles of which it is composed, if we assume these particles to be spherical and of uniform size. Consequently, while, as we have seen, the volume of the interstitial space is independent of the size of the particles, the area of the walls bounding this space increases enormously as the size of the particles diminish. These two facts, the independence of the volume of the interstitial space and the dependence of the surface area of the soil particles, on the size of the latter, are two of the main physical features of the soil which it is important for us to recognise, but which we must leave for further study at a later period.

We have so far considered the soil as that portion of the mineral matter of which the earth is composed which lies near

the surface. On the locality in which we are situated will depend very largely the nature of what we find if we dig down below this surface. Over large tracts of India we need only dig a short way before we come to hard surface of what is popularly known as rock; in others, such as the Gangetic plains, it is possible to go many hundreds of feet down before finding such rock. If in this latter we dig a trench a few feet deep only and examine the exposed surface, we will find an upper layer of, may be, a few inches in which the mineral particles are loosely laid together, and of which the colour is usually dark. Passing downwards, this gradually changes into a lighter coloured layer into which the roots of the plants growing on the surface penetrate, and this layer again, in its turn, passes into the undisturbed "rock" below. There are thus three layers distinguishable to which, as we pass down, we may give the names respectively of soil, subsoil, and rock. We must be careful to distinguish the exact meaning of the word rock as here used. We are accustomed to think of rock as something solid and hard to break, but this is not so; in some cases, as in the Gangetic plains, there is little or nothing to distinguish the rock from the subsoil; both will break down fairly readily into fine particles. Rock, then, is the undisturbed earth; in many cases it is true, it is hard and not easily broken up, but that is not an essential condition.

For a full understanding of rocks and their origin, a study of geology and physiography would be necessary. It is not, however, necessary to go so deeply into the subject here, and for our purpose we can consider rock to be either volcanic or alluvial in origin, the former the direct product of the cooling molten portion of the earth, the latter the product of the surface agencies, rain, frost, wind, etc., which break down earlier formed rock and deposit the particles elsewhere. Of the agencies working in this breaking down and building up of the earth's surface the most important is water, which carries away the loosened particles and redeposits them elsewhere. When first deposited the particles are loosely laid one on the other; but when other particles are deposited on the original ones, they become more firmly pressed together. Under the action

of such pressure, which will become great as the superimposed layer becomes thick, they will ultimately become firmly welded together in a hard rock.

When such rock becomes exposed by upheaval of the earth's surface it is subjected to the influence of the surface agencies we have already referred to and to the action of plants the seed of which fall on the exposed surface, germinates and sends roots into any cracks and interstices that may occur. The sum total of these influences is known as weathering, and results in the breaking up of the rock into loose particles with which become intermingled the remains of plants which have died on the surface. Whether these particles and these organic remains are carried away and fresh rock exposed, or whether they remain on the place of their formation, depends largely on the climate, the amount of rain, and the nature of the surface, flat or sloping. If this process of disintegration of the rock takes place more rapidly than the surface forces remove the particles formed, an accumulation of such particles, discoloured by the decomposing organic matter, will form on the surface and compose what we mean by the term soil. Below this, where the surface agencies are not so active, and the major effect is the action of the roots of plants, the change will not be so marked, and to this layer we apply the name of subsoil; it again will pass more or less sharply into the rock underneath.

Rock then consists of mineral particles closely appressed and adhering into a more or less solid block. If of volcanic origin there will usually be no interstitial space, but even in alluvial rock this will be reduced to a minimum, and may even be altogether absent. The gradual application of more and more pressure will grind down the particles, rounding off the angles and driving the fine particles thus formed into the interstices. In igneous rock the different minerals possess different capacities for withstanding the weathering action, and thus, on exposure, break down into fragments by the gradual removal of the less resistant constituents; while the alluvial rock, by the nature of its deposition and by the strain imposed in upheaval, possesses lines of weakness along which

the action of the weathering agencies will act most rapidly. Such weathering opens up in the subsoil cracks and fissures which become filled with a loose material, into which the roots of plants can penetrate to assist the disintegration, while in the soil itself the process is carried still further, and disintegration becomes complete. But even so the soil, as we have seen, does not consist of the ultimate particles in disunion, but of these aggregated into small groups in the manner we have described.

The correct understanding of this condition, which we may term the physical condition of the soil and its relation to the lower layers of the earth's surface is of considerable importance, since cultivation consists very largely in overturning the soil and consequently producing a re-arrangement of the soil particles with an accompanying increase in the volume of the interstitial space. One result of this is that it facilitates penetration of the root, especially the seedling root, but a more important result will be found later to lie in the influence of such tillage on the water relations of the soil.

CHAPTER IX

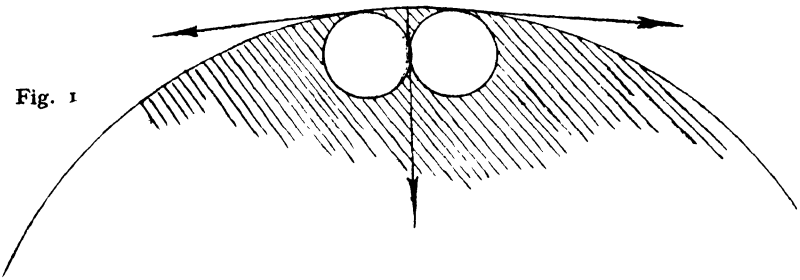
THE SOIL IN RELATION TO MOISTURE

THAT the soil is not usually dry, but moist, requires no delicate apparatus to determine. Freshly turned earth is usually dark in colour, and becomes lighter as the moisture evaporates and the soil dries. Pressed in the hand such soil binds together in a manner dry soil will not. If a more critical proof be desired, a known weight of fresh soil may be dried, by spreading in a fine layer or by heating, and re-weighed, when the loss of weight will indicate the amount of moisture originally contained. This moisture is not, however, sufficient, under ordinary circumstances, to fill the interstitial spaces; these are filled with air, and the moisture forms a film over the surface of the soil particles. As a result of this disposition, which exposes a large free water surface, the distribution of moisture throughout the soil is controlled by the laws of surface tension.

The attraction that exists between the molecules of which any liquid substance is composed causes the exposed surface to act as a stretched elastic film in which the attractions between one surface molecule and its neighbours must balance in all directions. The effect of such forces is to reduce the water surface, where possible, to a plane; or, where this is not possible, as in the case of a suspended drop, to a sphere. In the case of a drop the elastic film is convex. Here the resultant of the attractions on any particular molecule caused by the surrounding molecules is centripetal, exerting a pressure on the underlying liquid (Fig. 1). But it is possible to conceive of cases where the surface is concave and not convex. In such a case the resultant of the attractions will be centrifugal, exerting now a pull on the underlying liquid (Fig. 2). In both cases the magnitude of the force will be dependent on the extent of the curvature. Simple examples of these two cases are given

by the action of the two liquids, water and mercury, in capillary tubes. The former wets glass, the latter does not. In the former case the water surface is concave, and, consequently,

Fig. 1



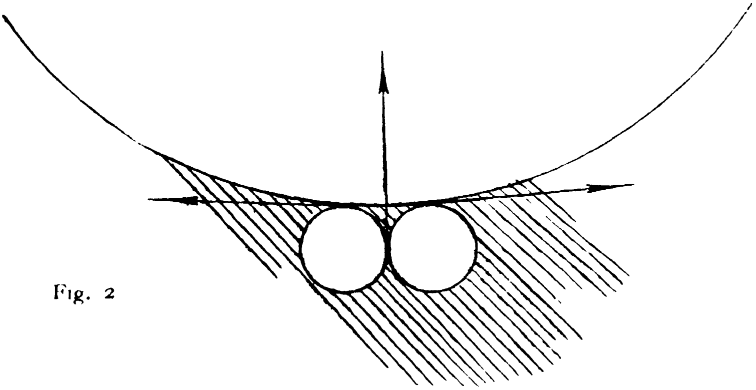


Fig. 2

exerts a pull on the underlying water which rises in the tube until this pull is counterbalanced by the weight of water supported ; in the latter case the mercury surface is convex, and consequently exerts a pressure on the underlying mercury,

which is depressed until this pressure is counterbalanced by the weight of the mercury displaced. The finer the capillary tube, the greater will be the curvature of the liquid surface and the height to which the water rises, or the depth to which the mercury is depressed, will be correspondingly great.

The above example illustrates that effect of surface tension, which is known as capillarity ; the rise or depression of liquid within a fine tube. As we have seen, the soil moisture is held in the converse manner, as a fine film surrounding the solid soil particles, and the effect of surface tension will be to bring

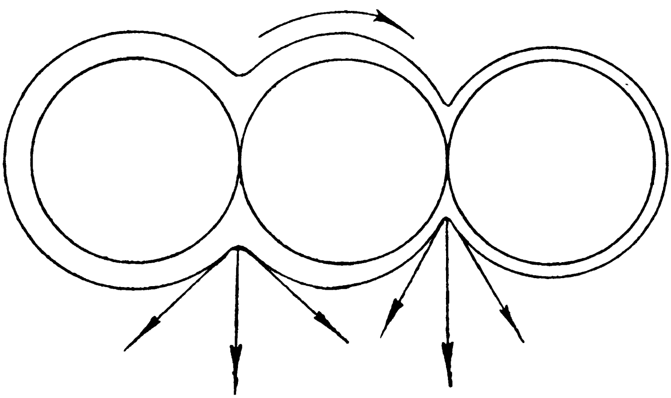


Fig. 3

the forces acting on any surface molecule into equilibrium ; in other words, to establish a surface curvature which causes the resultant of the surface attractions to counterbalance the thrust produced by the underlying molecules. We may consider a very simple case of three similar spherical soil particles in contact as in Fig. 3. At the point of union of the two films near the point of contact of two particles the water surface forms a re-entrant angle, thus becoming concave. While, therefore, the water surface elsewhere exerts a pressure on the molecules underlying the film, at the points of contact of the particles it will exert a pull thus causing the water to accumulate at these points. Equilibrium under such conditions as we have assumed will be reached when the film over all

the particles is of equal thickness and the amount of water accumulated at each point of contact is identical. If, now, water be added so as to increase the thickness of the film covering the particle at one end of the series, the curvature of the water surface at the junction of this with the central particle will be reduced and become less than the curvature at the junction of the central, with the third, particle. The pull exerted at the former will be less than the pull exercised at the latter junction. Consequently there will arise a flow of water in the direction of the thinnest film until equilibrium is re-established. In this manner there is established a regular flow of water from the point of high water content to any point of low content as the result of surface tension.

Surface tension, however, is not the only force controlling the distribution of water in the soil. A second is that force common to all earthly matter, gravity. Unlike surface tension, which acts in all directions, gravity acts in the downward direction only, and the actual distribution of water in the soil will be one in which equilibrium is established between these two. That equilibrium is represented, other things being equal, by an amount of water gradually increasing with the distance from the surface. The film of water thus becomes thicker and thicker, and the interstitial spaces smaller and smaller until, ultimately, they disappear. We have here a condition of saturation ; and the highest level of saturation, below which no air occurs, is known as the water table.

In nature, then, we have a soil exposed to the air above and passing into a subsoil, which, in its turn, passes into rock. If, as in the case of the Gangetic plains, that rock is not firmly compacted, but still retains a large volume of interstitial space, we have conditions which approximate to those we have described. In such cases a water table lies comparatively near the surface, and a condition of equilibrium between this and the water contained in the earth lying at a higher level may be practically established. Such a condition of equilibrium is, however, rare, and may be disturbed in many ways. The surface of the soil is exposed to the air and to air motion, leading to evaporation of the moisture surrounding the upper

soil particles; the resulting reduction of the film of water round these particles will, now, cause a flow from below upwards against the force of gravity. If, however, water is added to the soil surface, either as rain or irrigation water, a thickening of the film takes place and the flow of water in this case is downwards assisted by gravity. Such a downward flow is known as percolation. It is not, as we might suppose, a flow through the interstitial spaces, but a creeping through the film covering the particles. The soil, as we have seen, is rarely in a saturated condition; normally the interstitial spaces are filled with air and the water limited to a film covering the particles. If, now, rain falls on such a soil, the water will penetrate and saturate the surface layer, thus locking in the air contained in the lower layers. This enclosed air will limit the passage of water to the films we have already described as covering the surface of the soil particles.

Under normal circumstances the downward, and in all cases the upward, motion of water is controlled by surface tension. In the former case it is assisted, in the latter opposed, by gravity. Water will, therefore, descend to any depth, but the height of the column of water supported will be limited. If the soil be composed of coarse particles, the number of points of contact is small, and the tension developed is slight. As we have seen, a reduction in the size of the soil particles increases enormously the surface area exposed, and also the number of points of contact. In such soils the surface tension becomes a force of immense practical importance, lifting water to many feet above the water table. Up to a certain point, therefore, fineness of soil will aid the movement of soil moisture; but if the reduction of size be carried too far, as when the soil consists of the finest clay only, we come within the range of a further series of forces, those acting between individual molecules. If the particles have a diameter not exceeding ·0002 mm. it will be impossible for any molecule of water to be at a greater distance than ·00004 mm. from the surface of any soil particle, and all molecules of water will, thus, lie within the molecular forces exerted by the solid matter of the soil particles from which these extend to about ·00005 mm.

We find, therefore, a limit at which the fineness of the soil particles becomes a hindrance to the motion of soil moisture; it is, however, a limit which is rarely reached.

We must now try to form some idea of the extent to which this movement of soil moisture takes place in nature. Such an idea can only be very general, for the factors on which the movement depends will vary greatly in different soils and under different conditions. In addition to the factors already considered, percolation will depend in large measure on the nature of the surface and its condition with respect to soil moisture. If, as in the case of an unploughed field after the hot weather, the surface be hard, firmly compacted, and very dry to a depth of several inches, the first monsoon rain will, by saturating the surface layer and so enclosing the air contained in the interspaces, fail to penetrate to a depth where it will come into contact with the moisture still remaining in the lower layers, and no continuous film will, at first, be established. Under such circumstances and until such a continuous film, along which water can creep, is established, percolation will be slow; but, as soon as continuity of the film of moisture is established, percolation will increase rapidly.

Attempts to measure the amount of percolation have been made by means of what are known as drain gauges, in which solid blocks of undisturbed earth are enclosed in concrete walls and provided with a perforated floor through which excess water can drain away. Such drain gauges at Rothamsted show that, of 30 inches of rain, a little less than 50 per cent. percolates through 20 inches of soil and some 45 per cent. through 60 inches. Similar records for the drain gauges at Cawnpore give a percolation of about 38 and 36 per cent. of the rainfall—an amount which owes its relative smallness to the higher temperature and consequent larger loss by evaporation. Such records can, however, be only approximate; in the first place the perforated base offers a line of escape for the air within the soil, and penetration is likely to be advanced thereby; again, such gauges have to be built with a raised edge to prevent loss of soil by surface wash, and the prevention of this flow involves the retention on the surface, until ab-

sorbed by percolation or evaporation, of the water which would otherwise be removed by surface flow.

The upward movement of water due to surface tension is caused by the removal of water by evaporation from the upper layers of the soil. The extent of that evaporation will vary with various factors which we will consider later ; at present our object is to form some idea of the rate at which soil moisture can move through the soil, and such an idea will be given by measuring the amount of water which is evaporated in a given period and replaced from below, when the cause for that loss is removed.

It requires no skilled or deep knowledge to recognise that, in the variation of temperature which takes place between day and night and of such factors as air motion, we have a series of conditions which lead to rapid evaporation during the day and a slower one at night. This is especially marked at seasons when the temperature falls sufficiently to cause a deposit of dew as in October after the rains have ceased. Under such conditions evaporation will practically cease at night and any difference in the amount of soil moisture, as measured at such a time and as measured after the temperature has reached its daily maximum, will be due to loss by evaporation. If the former measurement be made subsequently to the latter, the difference will measure the amount of moisture which has passed up from below into the area in which the determination is made. Such a determination is given here, the morning sample being taken at 8 a.m., before the dew had evaporated, the afternoon sample at 2.30 p.m., when the temperature had reached a maximum. The date was the 23rd October and the locality Bihar.

PERCENTAGE OF MOISTURE IN SOIL SAMPLES.

	8th inch.	7th inch.	6th inch.	5th inch	4th inch.	3rd inch.	2nd inch.	1st inch.
8 a.m. 17th Oct.	19·56	17·27	15·37	14·35	13·29	13·33	12·29	9·35
8 a.m. 23rd Oct.	19·26	16·33	14·14	12·62	12·21	11·91	11·07	8·96
Difference	·30	·94	1·23	1·73	1·08	1·42	1·22	·39
Average loss	1·04 per cent., equivalent to 11·1 tons per acre.							
2.30 p.m. 23rd Oct.	15·60	14·39	12·72	12·21	12·11	11·39	9·86	4·93
Diff. morn. & aft.	3·63	1·94	1·40	·41	·10	·52	1·21	4·03
Average loss	1·66 per cent., equivalent to 17·8 tons per acre.							

The loss here indicated is equivalent to a loss of over 17 tons of water from an acre during the 6½ hours which have elapsed between the morning and afternoon determination. Yet, in spite of this heavy loss, during the six days prior to the date of these determinations, the total loss indicated is only 11·1 tons. The only explanation of these results is that this large loss during the day is, in great measure, made good by an upward flow of water through the soil. Nor is this figure of 17·8 tons per acre a full measure of the actual loss due to the upward flow. It is the actual loss from the top 8 inches only. If we look at the figures closely, we will see that the loss is not confined to this superficial layer; had that been so, the difference between the moisture content would diminish with the depth, whereas it actually increases.

These figures are sufficient to give an approximate idea of the extent of the movement of soil moisture. Its magnitude will, in all probability, surprise most of us. But that very magnitude only emphasises the importance of control if the crop is to derive the maximum benefit from the available supply.

CHAPTER X

THE SOIL IN RELATION TO PLANT FOOD

IT has already been stated, and it is a fact which a few simple experiments on the living plant will teach us, that the plant derives the mineral matter it requires for its growth from the soil through the medium of the soil moisture. By means of water cultures and analysis of the plant we are able to distinguish what we may term the essential elements, elements, that is, without which plants are not able to grow, and the source of these. These essential elements may be grouped into those derived from the air or water, carbon, oxygen and hydrogen, and those derived from the soil either non-minerals, nitrogen, chlorine, sulphur and phosphorus; or minerals, potassium, calcium, magnesium and iron. Other elements may, of course, be found ; for any element found in the soil as a soluble compound will pass with the soil moisture into the plant until the concentration on either side of the permeable membrane formed by the living protoplasmic layer of the root hairs balance each other. We are, however, only concerned with the essential elements, salts containing which pass in like manner into the tissues of the plant. Since these are woven into the living matter of the plant and so removed from the sap, the entry of a further supply to replace the amount removed takes place, since concentration on either side of the protoplasmic membrane will never balance as long as there is a removal of the salts within the tissues.

The plant is, thus, continually removing from the soil these essential elements, and, if fertility is to be maintained, it is clear that the amount removed must be replaced. The plant, however, is only able to remove these elements when they occur in soluble form and pass into solution in the soil moisture. We have, therefore, to distinguish between the soluble, or what we may term available, and the insoluble,

or non-available, forms of plant food. For this reason a complete analysis of the soil offers but small information as to the probable fertility; even if we select a case where fertility appears to be independent of the physical condition of the soil, we may find that analysis indicates an ample supply of all essential elements. For example, analysis may show that an ample supply of phosphorus is present while the field not only shows low fertility but the crop responds readily to a dressing of phosphatic manure; to take a particular instance, a dressing equivalent to 60 lbs. phosphoric acid per acre may have a marked effect on the fertility of the field, though analysis shows that there is already some 2,000 to 3,000 lbs. phosphoric acid in the soil. The explanation of such a case lies in the fact that the phosphorus occurs in an insoluble, and, therefore, non-available, form. What is required, therefore, is, not a complete analysis of the soil, but an analysis of the soluble, or available, portion; but care is necessary even here, as subsequent considerations will show.

We have referred to the loss of soluble matter removed by the plant, but this is not the only loss. In hilly tracts a portion of the rain falling on the surface percolates through the soil and reappears in the form of springs. Such springs are common all along the foot-hills, and we have here a process of washing out of the soluble matter of the soil into the ground water and so into the open rivers. Even in the plains water will percolate through to the ground water and raise the water table to a height which will cause a lateral flow of water into the rivers. While there is, thus, a considerable direct loss of plant food due to these causes, there is, as we have seen, at certain times of the year a considerable flow, especially large in the case of soils of the Gangetic plains, of water from below upwards due to surface tension, and with this flow will be carried the salts in solution. The plant, therefore, is not dependent on the actual plant food available within reach of its roots; this may, on analysis, appear totally inadequate, but if there is a large flow of water from below upwards we will have to take into account the additional amount of plant food so brought within the radius of root action.

Analysis of the available plant food, as well as the response of a crop to certain manures, indicate that the soil in many cases has fallen to the minimum requirement of this for full development ; yet no case is known where the yield of a crop grows less and less until it becomes negligible. As experiments at Rothamsted have shown, there is a minimum crop which a field will continue to produce year after year, though no plant food is added. This minimum is produced in spite of the removal of plant food in the crop itself and in spite of the loss due to percolation. There is obviously, therefore, some means of replacing the plant food removed. Such replacement is in large part the result of what we have already referred to as weathering. We have seen how rock is decomposed by weathering and broken down into loose fragments by the removal of the more soluble portions. By this removal and by this breaking down into smaller particles the surface exposed to the weathering agents will be increased. These agents, consisting as they do chiefly of air, sunlight, frost in colder climates, carbon dioxide contained in rain water and the action of plant roots, are most vigorous near the surface of the soil. By these means non-available mineral matter is converted into available plant food, and on the rate of conversion will depend the size of the minimum crop obtainable.

We may now attempt to obtain some more accurate idea of the amount of plant food required to produce a full crop and compare this with the amount available. Analysis of a wheat crop indicates that the amount of phosphoric acid removed by an average crop is about 20 lbs. per acre and the corresponding amount of potash is 36 lbs. We have not hitherto considered such physical characters as the density of the soil, but we may accept it that the top 9 inches of an acre will weigh some 2,500,000 lbs., and that consequently a soil showing only 0·1 per cent. of phosphoric acid or of potash will contain some 2,500 lbs. of either substance. The actual percentage of these substances is very variable in different soils, but 0·1 per cent. is not a high figure, and such soils will contain, in the top 9 inches only, sufficient phosphoric acid to produce a wheat crop for 125 years. Though the top 9 inches of soil includes

that portion in which the weathering agents are most active, the plant, as we have seen, is in no way limited to the top 9 inches for its food supply, and there is, therefore, an almost inexhaustible supply of phosphorus available. Rarely, therefore, are we concerned with the gross amount of the essential elements present in the soil; what we are concerned with is the rate at which they are rendered available and with the prevention of loss after they have been reduced to a soluble form.

The rate at which such conversion will take place is dependent on many factors. Essentially each is a chemical action, and will depend primarily on the factors by which such actions are controlled. These have certain features in common which influence the rate at which they take place. Thus the rate of conversion will increase with the surface exposed, that is, with the fineness of the soil particles which, as we have seen, is associated with increased surface area. It will also increase with the extra exposure to light and air given by cultivation; for, of the weathering agents, not the least is the oxygen of the air, and the larger the surface to which free access of air is provided, the greater will be the action produced. It will, again, increase with temperature, for increased temperature is usually associated with enhanced chemical action, and, consequently, the replacement of available plant food from the insoluble constituents of the soil will be more rapid in a hot or tropical climate than in a temperate one.

Prevention of loss of soluble mineral matter in the soil is a problem intimately connected with a phenomenon which we must now briefly consider, and which is known as absorption. We have stated that soluble mineral salts are conveyed with the flow of soil moisture which we know to take place through the films covering the soil particles. That statement is, however, only partially true. If we take a column of earth, allow a salt solution to percolate through it and analyse the liquid obtained by percolation, we will find that the soil has retained a portion of the salt contained in the original solution. The extent to which a salt is so absorbed will depend, in part, on the salt itself, and, in part, on the nature of the soil. This

capacity of absorbing certain salts is a complex phenomenon. In certain cases it is a chemical action, as when the base is retained and the acid drains through; here a definite chemical action is involved. In others it is physical, as in the case of phosphates. Here the molecule is not decomposed, but held by some physical force which we cannot define in great detail here. It is only within recent times that our knowledge of what are known as colloids has become very definite. The name is used to denote bodies, like glue, which tend to form jellies, but recent investigation indicates that the colloidal properties are the result of the physical state and are not characteristic of the substance. Many substances which do not normally show the properties of colloids can be made to do so, in other words, can be brought into the colloidal condition. Certain substances in the soil, notably clay and humus, exhibit this colloidal condition, the most important feature of which is the power to absorb substances from solution, a phenomenon usually termed adsorption. We may think of it most readily as a power to precipitate the adsorbed body on the surface of the colloidal substance.

But while the molecule is so held it must not be assumed that it is rigidly held. That the salts in solution are carried with the movement of soil moisture is still true, but there occurs a lag in the movement of the salt owing to this absorption, and the magnitude of this lag depends, for a particular soil, on the nature of the salts under consideration and on the amount of colloidal substance present. Of the salts with which we are chiefly concerned as containing the essential elements of plant food soluble organic nitrogenous compounds, ammonia, free or in combination, phosphoric acid and potash are very completely absorbed by most soils; while nitrates, sulphates, chlorides and the bases calcium and sodium are not retained to the same extent. The correctness of this conclusion may be demonstrated in many ways. Analysis of the percolation water obtained in the drain gauges, to which reference has already been made, and of the percolation water from drains set below the surface, indicate the selective action of the soil for particular salts. Such drains, though common

in England, are not found in India; under the climatic conditions of India the same selective capacity of soils to absorb salts is illustrated in a totally different manner. Here a large proportion of the rain passing into the soil by percolation returns to the surface in the subsequent dry weather to be evaporated. The soluble salts produced in the surface layer, as the result of the weathering, are carried down into the soil. Those for which the soil shows least absorptive capacity will be carried lowest, and may even reach the ground water and be carried away by lateral movement, or they may be returned to the surface, being carried with the water subsequently raised by surface tension. Under conditions where the chemical constitution of the soil particles leads, on weathering, to the production of a large amount of soluble salts for which the soil shows little absorptive capacity, and under conditions where rainfall is insufficient to carry these salts into the ground water and remove them entirely by direct discharge into springs or rivers, these salts will be carried down a certain distance into the soil merely to reappear on the surface as the water which conveyed them evaporates off. In marked cases they form an efflorescence on the surface which is found to consist almost entirely of salts such as sodium chloride, sodium sulphate or sodium carbonate; all salts which, as we have seen, the soil does not absorb. Lands showing such efflorescence are termed alkali lands, and, in the western districts of the United Provinces, they occur over wide areas. It is this efflorescence which is know as reh.

Such alkali lands are usually barren, but this barrenness does not necessarily imply an absence of plant food. The presence of sufficient salt to produce an efflorescence on the soil surface necessarily implies that at least the first water to pass into the soil from above will be a saturated solution of these salts, and the roots of any plants growing on such an area will be brought into contact with this saturated solution. Again, on the return of dry weather with consequent evaporation, the concentration of the superficial soil moisture will again increase until saturation is reached. The first effect of such immersion will be to plasmolyse the contents of the root hairs. Few

plants are able to withstand such salt concentration, and die under the exposure. While, therefore, on such land, vegetation and even crops may grow during the rains, the increased concentration which follows their cessation will kill all but the few species, of which the best known are the salt bushes (Atriplex), which can withstand the effects of such concentration. It follows, however, that such salts will be the first to be removed by any system of washing the soil, such as has been used for the reclamation of alkali lands, and that it is possible to wash out these harmful salts while leaving the major portion of those salts which form the food of plants in the soil.

CHAPTER XI

THE BACTERIA OF THE SOIL

WE are able to prove by means of water cultures that nitrogen is one of the essential elements of plant food, and further investigation along these lines will show us that the only form in which nitrogen is available as plant food is nitrate. Yet, as we have seen, nitrates are among the salts which are least absorbed by soil, and are consequently one of those most readily lost. On the other hand no one with the least acquaintance with agricultural or garden practice is ignorant of the value of organic matter such as stable litter, or the common cakes left, after the extraction of oil, as manure. The value of such substances is largely due to the nitrogen contained in them. To those who have experience of artificial manures the use of ammonium sulphate as well as of nitrates as a source of nitrogenous plant food will be equally well known. Yet analysis will show that but a small portion of the nitrogen in the former organic manures, and none in the case of ammonium sulphate, is in the form of nitrate, which we have seen to be the only form in which nitrogen is available to plants. The question of nitrogen, therefore, stands out as distinct from the other essential elements of plant food.

Analyses will show us that the total nitrogen of the soil rapidly diminishes with the distance from the soil surface; it will, further, show very marked variations in the amount of nitrogen held as nitrate in samples taken at different seasons and at different stages in the rotation of the field. We may compare a total nitrogen content of 8 lbs. in the surface two feet of an acre which had just produced a crop of barley, with a weight of 273 lbs. in a similar field which had been left fallow. Such variations are too large to be explained by the conversion of insoluble, and consequently non-available, nitrogenous substances into soluble nitrates. There is clearly some other phenomenon at work which, since the nitrogen is mainly accumulated near the surface, is most active here.

The soil is constantly receiving additions of organic matter to the surface layers either naturally in the dead leaves, the residue of plants which have grown and died, the droppings

of wild animals and such like, or artificially in the roots left after the crop is cut, in the spreading of stable refuse and artificial manures such as cakes, or in the ploughing in of a green crop. These supplies of organic matter, very frequently highly nitrogenous, undergo rapid decomposition into what is commonly known as humus, the presence of which imparts a dark colour to the superficial layers of the soil. This decomposition, which leads ultimately to the formation of nitrates, is due to the action of minute organisms, known as bacteria, which occur in the upper layers of the soil, and especially in the loose soil. We cannot enter into the proof of this conclusion here, but, if we accept the fact, we will have no difficulty in understanding that the production of nitrates, nitrification as it is called, will depend on the conditions in the soil as affecting the development of the bacteria; for bacteria are living organisms for which there are optimal conditions of growth.

We must not jump to the conclusion that the bacteria which are responsible for nitrification are the only bacteria in the soil, or even the only ones that affect the nitrogenous substances of the soil. A few simple experiments, which we can now consider, will show that nitrate formation is only one stage, and not even the end stage, of a series of changes; and that it is possible as readily to develop bacterial action which will destroy the nitrates already existing in the soil.

A standard medium containing potassium phosphate (0·2 g.), magnesium sulphate (0·1 g.), sodium chloride (0·1 g.) in a litre of water with a few drops of a solution of ferric chloride contains all the essentials for bacterial growth, with the exception of nitrogen. To a litre of such solution we may add 2 g. of ammonium sulphate, and of the medium so produced take four flasks of about 300 c.c. capacity and treat them as follows:—

I.	II.	III.	IV.
control.	add 1 g. fresh soil.	add 1 g. fresh soil.	add 1 g. fresh soil.
———	———	add ·5 g. $CaCO_3$	add ·5 g. $CaCO_3$
———	———	———	heat to sterilise.

100 c.c. in each flask, plug and sterilise.

Set aside in a warm dark place for about one month

On completion of the month the four flasks are tested for nitrates. Flask 1 will be found to contain no nitrate, and only the original ammonia; the fourth flask will similarly show no change from ammonia to nitrate; while the third will show an abundance of nitrate, possibly to the exclusion of ammonia. Clearly some agent, which is present in the soil, but of which the activity is checked by heat, has converted the ammonia in flask 3 to nitrate. The second flask may, or may not, show this conversion, indicating an increased activity of the action in a slightly alkaline medium. The agency is the bacteria of the soil, and that their action is not limited to the conversion of ammonia to nitrate can be shown simply by taking a long glass tube, filling it with porous material such as chalk, which will maintain the alkalinity of the mass, seeding it with soil, and allowing a slow stream of dilute urine or liquid manure to percolate from above. The drainage will be found, after sufficient time has been allowed to elapse for a vigorous growth of bacteria to develop, to contain nitrogen almost entirely in the form of nitrate. Here bacteria break down simple nitrogenous organic substances with the formation of nitrate.

In the former experiment the flasks are open to the air through the cotton plugs, in the latter through the open ends of the tube and the contained air. The nitrification process is, thus, an aerobic one, that is, one which takes place in the presence of air. A similar experiment to the above may be carried out in which the ammonium sulphate is replaced by peptone, a more complex nitrogenous organic substance than those hitherto used. If the flask be examined at the end of a week the contents will be found to have that evil smell which we associate with the decomposition of flesh as the result of putrefaction. After the lapse of another interval, if the flask be again examined, this smell will have disappeared and be replaced by the odour of ammonia indicating that a further change has taken place. A further interval will lead to the disappearance of this smell also and the nitrogen will be found to be present in the form of nitrate. There is, thus, a series of stages in the process of the breaking down of highly complex organic substances which ends in nitrate, and this process is,

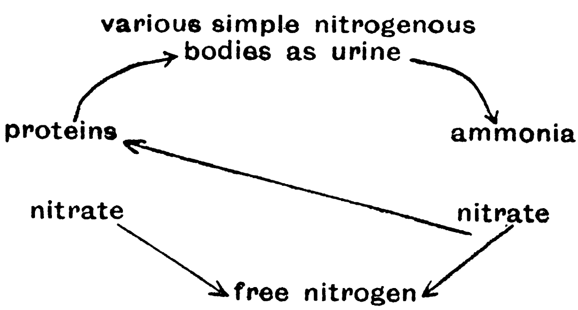
at each stage, aerobic. It is a process converse to the activity of the green plant which builds up those complex bodies from simple inorganic substances. This the latter experiment will show if the flask now be left in a bright light; a development of green algae will take place which will be accompanied by a diminution of the nitrate content of the solution.

The above are not, however, the only forms of bacterial activity to which nitrogenous substances are subjected. Into a litre flask containing 25 g. sugar and 0·1 g. potassium nitrate a few grams of soil are placed and the flask closed with a cork from which a conducting tube leads to a receptacle for gas, the whole being fitted up so that the flask retains no air. In the course of time, at a suitable temperature and in the dark, gas will begin to collect in sufficient quantity to be tested, when it will be found to be largely composed of nitrogen. A bacterial decomposition of nitrate is, thus, taking place, and the conditions of the experiment indicate that the decomposition is an anaerobic one, that is, one which takes place in the absence of air.

We can now consider as a whole these various phases in this decomposition of nitrogenous substances. Starting with the most complex of such bodies found in organisms, to which the name proteins is given as indicating a somewhat ill-defined series of organic bodies, by a series of stages, which are aerobic, we arrive, through simpler and simpler substances, at ammonia, and ultimately at nitrate. That nitrate, we have seen, the living plant, to use the term in its popular acceptation, takes up through its roots and rebuilds into those complex organic bodies from which the nitrates were derived. There exists, thus, what we may term a nitrogen cycle composed of a synthesis of proteins by the living plant and a destruction of the substances so produced by the living animal and by bacteria, a cycle which, of itself, would provide the nitrogen required by organisms from the various substances in which nitrogen exists in the combined form.

Such an origin of organic nitrogen would, of necessity, place a limit to the amount of organic matter on the face of the globe, and this is not in accordance with the facts of reproduction

such as we have seen them to be. There is, further, the anaerobic action of bacteria to be taken into account, which leads to the destruction of nitrate with the liberation of free nitrogen. This is a process which, unless some counteracting conversion of free nitrogen into nitrate is also taking place simultaneously, would lead to an actual decrease in the stock of combined nitrogen, and, consequently, in the organic matter producable by living organisms. We cannot here trace in detail the proof of the existence of that change, nor the proof that the agent is again a bacterium. There are, in fact, many "nitrogen fixing" bacteria, and certain of these are free living and derive the energy they require from the decomposition of the carbohydrates contained in the plant residues in the soils. Others, and these are especially important from the agricultural aspect, can only develop actively in association with the roots of leguminous plants. The advantage of leguminous plants in a rotation has been known to cultivators in many countries from remote times, and it depends on the fact that these afford an opportunity for the bacteria to become active, with the result that such a crop, unlike other crops, enriches the soil in nitrogenous substances. In India, in all probability, the practice of mixed cropping is in part due to an unconscious recognition of the benefit derived from the leguminous member of the mixture. This complex nitrogen cycle we can illustrate in the following manner :—



We may regard this nitrogen cycle from another aspect, namely, that of energy. Speaking, for the sake of simplicity,

in general terms, such complex bodies as proteins require a considerable amount of energy for their synthesis. The ultimate source of energy for the vital processes of all organisms is the light derived from the sun's rays. Under exposure to these rays the green plant builds up carbohydrates, chiefly starch and sugar, with the liberation of oxygen, a process known as assimilation. By the energy released with the destruction of a portion of these carbohydrates, the complex organic bodies found in the plant are formed and the non-living framework of cell walls is laid down. That destruction of carbohydrates, whether it be direct or indirect after conversion to more complex bodies, is the process of respiration characterised by that evolution of carbon dioxide which is recognisable at night when assimilation ceases, but which is masked in the day-time by the oxygen evolved as the result of the assimilatory process. The bodies so built up by the plant, carbohydrates, oils, proteins and such like, may pass into the seed when, on germination, their destruction liberates energy for the growth of the seedling until this becomes self-supporting; or they may be consumed with the plant by animals, when their destruction liberates the energy required for the growth, maintenance of body temperature and activity of these. In the latter case the end products are the faeces, composing the constituents of the plant incapable of digestion by the animal, the urine, the lowest stage to which the animal carries the decomposition of nitrogenous substances, and carbon dioxide, the end product of the oxidation of carbohydrates and other non-nitrogenous organic substances. Or, lastly, the plant may die, when bacterial action will not only accomplish those decompositions which the animal effects, but will carry these still further, in the case of nitrogenous substances, to nitrates, and even free nitrogen; the energy so liberated providing, in part, the necessary stimulation for bacterial growth and development.

In similar manner the formation of nitrate from free nitrogen is a reaction which requires energy for its performance, and that energy is provided by the destruction of non-nitrogenous organic matter existing in the soil humus or placed by the

leguminous host within reach of the bacteria living in close symbiosis with the plant's roots.

In the course of our discussion of bacterial action from the aspect of the source of energy required to bring about certain chemical changes, we have noted that bacteria can effect a decomposition of dead plant matter; and again, that other bacteria can derive energy to fix free nitrogen by the decomposition of carbohydrates. That bacteria are able to bring about the total decomposition of the animal body is also a fact of every-day observation. But such plant and animal tissues are largely built up of non-nitrogenous substances, and we have not tested the truth of the statement that the decomposition of such non-nitrogenous substances can be effected by bacteria. In the last experiment described above, in which the anaerobic action of denitrification by bacteria was considered, we saw that the gas was largely composed of nitrogen. Had we shaken up that gas with lime water we should have learned that it contained also carbon dioxide derived from the sugar supplied. The destruction of carbohydrates may, however, be more clearly demonstrated by placing moist soil in which sugar is incorporated in a tube through which air can be drawn at intervals. If the air so drawn off be passed through lime water, the precipitation of carbonate will occur, indicating a large evolution of carbon dioxide derived from the sugar mixed in the soil. In this case the action is aerobic, a case of direct oxidation. In the former experiment it is anaerobic.

The soil is, thus, a field of activity for bacterial action which exhibits itself in numerous chemical reactions, not the least in extent or importance being those affecting the nitrogenous substances found therein. We have seen sufficient in the course of this brief description to understand that the physical condition of the soil, and, consequently, the art of cultivation, will largely influence the form in which, and the extent to which, nitrogen will occur.

CHAPTER XII

THE ATMOSPHERE AND PLANT LIFE.

IN the last few chapers we have considered the most important features of the soil, and that portion of the plant's surroundings with which the descending portion, or root, comes into contact. The plant has also an ascending axis, or shoot, which comes into intimate contact with the air, and which is responsible for the supply of carbon required to build up the organic tissues, both living and dead, of the plant.

Regulated by the stomata, which occur chiefly on the lower surface of the leaves, the carbon dioxide diffuses into the intercellular spaces of the spongy parenchyma of the leaf, is there absorbed, and, under the influence of chlorophyll in the presence of light, built up into starch. That starch is subsequently converted into sugar, and in this form translocated throughout the plant wherever living protoplasm requires food material for its activities. For that diffusion to take place the stomata must remain open, but these stomata are also the channel for the evaporation of the water taken in by the transpiration current. The volume of this water is very large, amounting to some hundred times the weight of the dry matter of the plant ; nevertheless it requires regulation, or the loss of water may exceed the amount taken up by the roots and the plant wither. Such control is provided by the stomata.

The rate of diffusion of moisture from the air contained in the intercellular spaces to the external atmosphere will depend, among other things, on the amount of moisture contained in the air and on the temperature. In a dry warm atmosphere diffusion will increase until the loss of water from the cells of the leaf tends to become more rapid than their gain of water by means of the transpiration current. Under such circumstances the stomata will close, and, in doing so, will prevent the access of air and the contained carbon dioxide to

the intercellular spaces. Under these conditions, assimilation, that is, the formation of starch, will cease, but we should notice that this check to assimilation is an indirect one, and that the primary reason for the closing of the stomata is the checking of excessive loss of moisture from the tissues.

Air moisture, thus, has a very direct effect on the growth of a plant; and a dry, hot atmosphere, such as occurs in May in the plains, will frequently be found to check growth, even when ample moisture is supplied to the roots. The sudden stimulus to growth which we see in the sugar cane, for instance, on the arrival of the rains, even though the crop has been repeatedly irrigated throughout the hot weather, is an instance of this phenomenon. Through the hot season, though the plant has had ample water for the supply of the oxygen, hydrogen and mineral salts necessary for development, and has had the warmth and light necessary for rapid assimilation, growth cannot take place because the stomata are for the most part closed, and access of carbon dioxide checked. On the arrival of the moist monsoon winds the difference between the humidity of the atmosphere and that of the intercellular spaces is much reduced, diffusion is not so rapid that the transpiration current cannot keep pace with loss of water, the stomata do not close, and, consequently, diffusion of carbon dioxide and, with it, assimilation can proceed without interruption. The total food material produced in the course of a day is, thus, largely increased, and growth becomes rapid.

Such is the direct action of air moisture on the plant. It is not, however, the only aspect of air humidity with which the agriculturist is concerned. The soil, as we have seen, contains moisture in the form of a film over the surface of the particles, and a large water surface is exposed to the air in the interstices. This air is in direct communication with the free atmosphere, and diffusion of water vapour will take place between the two. The speed of this will depend on the dryness of the atmosphere; the temperature and the rate at which the water evaporated from the film is replaced from below by water raised by the action of surface tension. As with the leaf, the rate of evaporation may exceed the rate at which the evaporated water can be

replaced, and, under such circumstances, the moisture in the upper layers of the soil will fall, for there is nothing corresponding to the stomata of the leaf by which the rate of evaporation will be automatically regulated.

Both the direct action of air humidity on the plant and on the soil will be increased by air motion. In a still air, moisture will merely diffuse from the relatively moist interstitial air, whether of the leaf or of the soil, to the drier atmosphere ; the humidity of the air surrounding the leaf or in contact with the soil surface will be raised, and diffusion consequently reduced. Not only will air motion, by replacing this more humid by drier air, maintain diffusion at a constant speed, but it will provide a suction by which the moister air will be drawn from the interstices and replaced by drier air.

Such are the more intimate aspects of the humidity of the air in its relation to the plant and agriculture generally. We must not, however, overlook the broader aspects, the close inter-relation between the humidity of the air and climate. Though, as we have seen, a certain amount is derived both from the soil and from vegetation, the main source of the water vapour which produces this humidity is the free water surfaces, especially, owing to the relatively large area exposed, the sea. The amount of moisture the air is able to retain in the form of vapour depends in large measure on the temperature, and the greatest humidity will consequently develop over hot tropical seas. From here the air currents carry the water vapour landwards, and the upward set of these currents brings the vapour into contact with the cooler air, which possesses a lower capacity for retaining moisture, and causes the excess to be deposited as rain. The climate of any particular tract, and, consequently, the agriculture, will depend, therefore, in large measure on the direction of these currents. To appreciate the importance of any discovery of the causes controlling these currents which would enable forecasts of the weather to be made with certainty, we need only consider the effect that would be produced on agriculture if the cultivator knew beforehand what the nature of the monsoon was to be. While the study of meteorology has proceeded far enough to render rough

forecasts possible, our knowledge of the cause of meteorological phenomena has not advanced sufficiently to make these forecasts accurate to that detail which would be required to form the guiding principle of the cultivator. We cannot do more here than draw attention to the close relation that exists between the direction of these currents and the seasons.

We have had repeated occasion, in the above discussion of air moisture, to refer to temperature as a concomitant cause in the production of the effects noted. Temperature has a further direct effect on the plant in regulating the speed at which the vital processes, such as assimilation and respiration, take place. It has also an indirect effect on the soil.

The temperature of the soil is dependent on three factors: heat derived from within the earth, heat derived from the decay of organic matter, and heat received from the sun by radiation. That the last of these is the most important from the practical aspect is indicated by the general dependence of temperature on latitude. The former, however, is responsible for the maintenance of the general average temperature on which the fluctuations observed are produced by the influence of the sun. The decay of organic matter, while it is responsible for a considerable amount of heat, has, under normal agricultural conditions, small effect. As we know, a log of wood, when burnt, produces a considerable amount of heat; and the same amount of heat is liberated when the log is decomposed by natural agencies. Both processes are the breaking down of complex organic substances into simpler chemical products such as carbon dioxide and water; but the heat liberated in a few minutes in the former case is, in the latter, liberated only in the course of months or even years. The essential similarity is indicated where organic matter is collected under conditions favouring decomposition, as in a manure pit or a "buje" of grass or bhusa piled when damp. Under these conditions the heat evolved may be sufficient to set fire to the decomposing mass.

The actual temperature of the soil or air at any moment or place will be the resultant of many influences on the energy derived from the sun. Before the sun's rays reach the earth's

surface they have to pass through the atmosphere, which absorbs a certain amount of energy to appear as heat. The amount of energy so absorbed will depend very largely on the amount of moisture contained in the air. The specific heat of water is high; in other words, a considerably larger amount of energy is required to raise a given weight of water one degree than to raise the same weight of, let us say, iron the same amount, consequently the amount of energy absorbed in the passage of the sun's rays through a moist atmosphere must be considerably larger than the amount absorbed when the atmosphere is dry, if the same rise of temperature is to be attained. The temperature of the soil will now depend primarily on how much of the residual energy falls upon a given area, an amount which will depend on the angle at which the sun's rays meet the earth's surface. Excluding the daily variation of this angle, due to the daily rotation of the earth, the most important variation is that which is dependent on the general curvature of the earth's surface. It is this curvature which is responsible for that observed gradual lowering of temperature as the distance from the equator is increased. A second cause of variation is dependent on the slope of the ground, and is of importance in those latitudes where solar energy is barely sufficient to mature the crop. Under such circumstances this slope of the ground, or what is commonly known as aspect, may be the deciding factor in determining whether a particular crop can be grown. A similar condition obtains in the hills where the cultivation is largely controlled by considerations of aspect.

Secondarily, temperature will depend on how much of the energy falling on the earth's surface is absorbed, and how much reflected to be lost after a return passage through the atmosphere. This depends on what we may term physical properties of the soil, such as colour and conductivity. How far this absorbed energy will affect the actual temperature depends on what is known as the specific heat of the soil. For different soils the specific heat will vary, but the main source of variation is given by the water content. As we have seen in the case of the atmosphere, water has a high specific heat, and, consequently, it will require a larger amount of energy to raise the

temperature of a wet soil than will be required to raise a dry one to the same extent.

The process converse to the absorption of heat radiated from the sun is the loss of heat by radiation, with a consequent cooling of the soil and air at night. This process is most marked in a dry atmosphere and with a cloudless sky, and the greatest changes of temperature will occur with a dry soil and a clear dry atmosphere. The former requires a minimum of energy to produce a maximum temperature effect, while the latter facilitates both a maximum of energy, reaching the soil during the day and leaving it during the night. The change from the high maxima and low minima, showing a range of some 25 to 30 degrees, typical of the hot weather, to the low maxima and high minima, showing frequently a range of some 5 degrees only, typical of the rains, is a familiar example of this phenomenon.

We have considered temperature as an atmospheric condition affecting mainly the shoot of the plant. The temperature of the atmosphere is, however, controlled by the temperature of the soil. It is the soil, or the vegetation upon it, rather than the atmosphere itself, which is the main absorbing agent. As with air moisture, we are able to trace seasonal variations producing the major climatic effects, but there is also the daily variation, having no little agricultural significance, which has to be considered. We may mention as illustration the critical condition when, under an excessive fall at night, due to radiation, the temperature reaches freezing point, leading to injury to the crop.

Chapter XIII

THE PLANT AND THE UNCONTROLLABLE CONDITIONS OF ITS ENVIRONMENT

The outward and visible sign of the possession by an organism of that function to which we apply the name living will differ with the different organisms. In the higher animals the most prominent characteristic of the healthy organism is mobility, the capacity to move. Less prominent, but equally characteristic, in man, is the maintenance of the body at a temperature which does not vary with changes in the temperature of the surrounding air. But, whatever the manner in which an organism demonstrates its claim to be classed as living, it will be found that a consumption of energy forms an essential feature of the process. The maintenance of a body temperature above that of the air, and the physical effort involved in motion, both imply work and the consumption of energy.

Plants are commonly fixed and immobile, and we find that the most obvious characteristic by which they may be classed as living organisms, is one which is, in animals, only apparent in youth, that is, growth. Growth, however, implies the formation of complex substances, implies chemical action for which energy is required, and that energy is supplied by the destruction of other chemical substances. This process of destructive metabolism, of which the outward appearance is respiration, can therefore, only continue so long as suitable material is available for combustion. In the case of animals this is provided by the consumption of food, which must consist of complex substances, capable of direct destruction by the organism. In the case of the plant the supply is found in the end products of a series of relatively simple chemical actions, to which we may apply the name constructive metabolism, the energy for forming which is provided by the sun's rays. This form of constructive metabolism, most prominently represented by assimilation, is thus limited to plants, the " food " of which consists of those comparatively simple substances which form the raw material of the constructive process.

While in the animal we have merely a destructive process, the energy for which has to be derived from without, we have in the plant side by side a destructive, and a constructive, process, and we may consider the relation between the two. This relation will be clearest if we commence with a consideration of animals in which the destructive process is continuous and the supply of food from without. Without a regular supply of food the animal will not remain healthy ; for destructive metabolism, and with it the liberation of energy, will be checked. The same relation must also hold with plants, but the interdependence is not so clear. The plant's most obvious claim to be considered an organism has been seen to be growth ; it is most probably that function which absorbs the major portion of the energy liberated by destructive metabolism. But growth is not an essential function of living matter ; it may be checked, or even cease entirely for a period, without death resulting. A cessation of constructive metabolism, leading to a reduction, or even temporary cessation, of the food supply, may not necessarily, therefore, lead to death or even to disease. Again, it is possible that constructive metabolism may proceed at a pace which exceeds the consumption of the substances formed. Such a condition, if long maintained, will lead to an accumulation of food material in the plant which will permit growth to take place later, although constructive metabolism may have ceased.

There is, thus, no direct correlation between the time of occurrence of constructive, and of destructive, metabolism in plants such as is found in animals between the absorption and digestion of food. Instances of such lack of correlation will readily occur to us. The cactus (nag phani) plant may be cut down and allowed to lie for months in a dry place, yet it will grow into a healthy plant when replanted ; growth does not occur, and the energy required to maintain the other processes of living matter is sufficiently small to be provided by the food reserves contained in the tissues. In the carrot, as in most biennials, constructive metabolism during the first. year largely exceeds the consumption of food produced, and the excess food is stored to permit of the vigorous growth which

takes place when the plant flowers. The same phenomenon is exhibited in an even more startling manner in the agave. Nevertheless, in the large majority of annual plants, and most agricultural plants answer to this description, no considerable power exists for storing reserve food material; and duration of life is too short to admit of any considerable check to growth if the life history is to be worked out in the season. In such cases a close correlation is exhibited between the two forms of metabolism, and healthy growth is dependent on a continuous supply of the raw materials for constructive metabolism.

Even in those plants which build up a food reserve, that reserve usually consists of the products of assimilation. It lacks those mineral substances which we have seen to be necessary for growth, and we will find that growth will cease when the supply of those mineral matters is checked, even when the reserves stored in the tissues are large. We must be careful here to distinguish between growth as here meant, that is, vegetative growth, and growth merely for the purpose of reproduction. The former is the production of additional tissue; the latter, it is true, is the production of new tissue, but that tissue is not necessarily additional. Such growth as takes place when the carrot flowers or the agave poles is more in the nature of a transfer of material; in the former case from the roots, in the latter case from the leaves, to the seed; the minimum material sufficient to support the inflorescence is alone diverted for that purpose. This growth does not necessarily involve the absorption of more food material, and more probably consists merely in its redistribution, the energy for which is supplied by the destruction of a portion of the reserve product of assimilation.

Thus it comes about that the supply of a full dietary, on which true growth can take place, will only be completed when the water absorbed by the roots of the plant is sufficient to provide the full amount of these inorganic salts which we have seen to be essential for the plant. For this reason the water factor, by which name we may term the provision of a regular supply of salt-bearing soil moisture, forms one of the most

important considerations in the production of a healthy plant. The importance of cultivation lies very largely in the fact that, by it, the soil moisture is to some degree controlled. There is, however, another aspect of the plant to which we must devote our attention for a short space in passing. Every cultivator is aware that it would be useless to sow wheat in the United Provinces at the beginning of the rains, and equally useless to sow cotton in October. In the like manner he will not sow grain on rich irrigated lands, or sugarcane in poor sandy soils. The plant is thus brought into contact with two sets of conditions, the major, seasonal, or, as we may term them, climatic, dependent ultimately on extra terrestrial or meteorological, conditions; and the minor, local conditions traceable to the physical and chemical conditions of the soil. It is true that no sharp line can be drawn between these two. Soil moisture, for instance, forms a connecting link, depending as it does very largely on the rainfall, yet affecting the supply of food material which reaches the plant. Nevertheless the distinction is sufficiently marked, and we will obtain the clearest understanding of the limitations to plant-growth by tracing the relation between the plant and climate.

Let us first obtain a clearer understanding of what we mean by climate. The main feature of climate is that, while it is subject to large fluctuations in point of time, as in the major seasonal variation from rains to cold weather, from cold weather to hot, and from hot to rains, there is no large lateral discontinuity. As we pass from one place to another the change is gradual. If we travel from Bengal to the Punjab by way of the Ganges we find a gradual and progressive decrease in the rainfall, a gradual and progressive increase in the intensity of the heat and of the dryness of the air in May and June, and a gradual and progressive increase in the intensity of the cold of December to February. But this change is gradual; while the climates of Calcutta and Lahore show a marked difference, the various stages of which that divergence is built up, as between Cawnpore and Allahabad for instance, show no such marked difference. Even when we make the rapid ascent from the plains to the Himalayas this remains so, though

to a minor extent. We may contrast this continuity with the condition of the soil, of which we may almost say that discontinuity is a characteristic feature. Within a few feet the soil will frequently show large variations, both chemical and physical.

For simplicity's sake we may consider the case of a mosaic of discontinuous soil types of sufficient lateral extent to be subjected to different climatic influences; and again, we may use the tract which passes from Bengal, through the United Provinces to the Punjab, as a practical illustration of what we mean. Throughout this tract the soil is alluvial; and though at any place it may vary from a heavy clay to a light sand, it consists of a very similar mosaic throughout. In other words, were the class of crops grown determined by soil alone, the same group of crops would be grown throughout. Such, however, is not the case, and it is our object now to trace the cause of those differences which are apparent in the crops grown.

Each species of plant has what we may term a specific optimum environment and a specific range of environment. As conditions diverge from the optimum, plant development will be less and less healthy until a point is reached when the plant will no longer survive. Such an optimum and such a range is as characteristic a feature of the species as any morphological character, though, indeed, not so readily determined. If that optimum coincides with the climatic conditions which prevail in the centre of a tract such as we have described, the lateral continuity to which we have referred as characteristic of climate will constitute an environment which becomes more and more removed from the optimum as we pass away from that centre, and which, consequently, becomes less and less suited to the plant until the conditions become so inimical that growth is no longer possible. In the case of agricultural plants the limit to cultivation is imposed, not by the limit of growth, but by the limit of profitable growth, a limit which is as indefinite as is the change in climate. Nevertheless, in spite of this indefiniteness, the fact of an optimal centre, with a high proportion of area under the crop concerned, and a surrounding tract, as we pass away from that centre, in

which the area under the crop grows less and less, is frequently recognised. We may illustrate this point by a reference to wheat in the tract we have selected as a practical illustration—the importance of wheat as a crop progressively diminishes as we pass from the Punjab east until, in Lower Bengal, its cultivation is practically discontinued. The same fact is noticeable in the case of cotton in the United Provinces. In Muttra the cotton crop forms a very large percentage of the kharif area, and, as we pass east, that percentage becomes progressively less until it disappears altogether in the Eastern Districts. It is not intended to imply that climate is the only factor influencing the area cultivated in these cases, but it is the controlling one.

We have so far considered the species as a unit with a specific optimum, but, in these species which have for long been cultivated by man, it is usually possible to recognise within the species races between which, not infrequently, the difference is not morphological but physiological; that is, a difference which affects the relation between the plant and its environment. Thus we have early and late races of wheat; races of rice which grow in standing water, and others which merely require irrigation, and so on. There thus lies, within the species, a series of races, each with its racial optimum and racial range, and it is possible, by a judicious selection of such races, to extend the area over which optimal results are procurable. Such action, however, will not materially affect the extent of the area over which the particular crop in question can be cultivated, it merely extends the central optimum area and makes the passage between this centre and the limits of practical cultivation more abrupt.

It is, therefore, practically necessary for the cultivator to recognise a limitation, determined by climate, to what he can grow. Again, from the practical point of view, perhaps the most prominent feature of climatic conditions is that they are uncontrollable by man, and it is only within the limits set by these conditions that man is able to adapt the environment to the special physiological requirement of the plant.

CHAPTER XIV

THE PLANT AND THE CONTROLLABLE CONDITIONS OF THE ENVIRONMENT

WE have so far considered climate as constant for a particular tract; or, to speak more accurately, constant in its variability. This expression, which may be found difficult of comprehension, is simply a brief method of stating that, according to our assumption, while season passes into season by a transition more or less gradual, similar seasons of successive years will be found to be alike. As we all know, such is far from being the case. The normal climate of any locality at any particular time is an average of a series of seasons occurring at that locality, but it by no means follows that that is the class of season which invariably, or even most commonly, occurs. At the limits of the range of cultivation, therefore, the practical aspect of cultivation is less whether the average climatic conditions will suit the plant than whether the number of favourable seasons exceeds the number in which the conditions are not favourable.

In addition to the seasonal change of climate there is also the diurnal variation of which the most important feature is the alternation of two periods. The one is characterised by the absorption of energy, when the food material is manufactured by means of the energy derived from the sun's rays; the second is characterised by the liberation of energy, when the energy required for the activities of the living organism is supplied by the destruction of food material built up during the day. These two processes differ in that the former is intermittent, masking during the period of its activity the latter, which is continuous. The diurnal variation is not, however, limited to the supply of energy; variation in temperature, and, with it, the degree of humidity of the atmosphere,

also takes place, and this fact exerts a considerable influence on the development of the plant. A brief reference has been made to this fact in Chapter XII., and a further reference will be made to it later on. For the present we must class the diurnal variation as one of those attributes to the climate of a locality which are beyond human control. They constitute a factor which has to be taken into consideration in selecting the crop suited to the locality. But such selection, as we have already pointed out, has, in most agricultural countries, already been effected and forms part of the experience of the agricultural community.

We may pass on to a consideration of the plant in relation to those local factors of its environment, the physical and chemical condition of the soil, of which the main feature we have seen to be a relative discontinuity. From the practical aspect, perhaps the most important characteristic of these factors is the fact that they are, in part at least, under the control of man. It is, for instance, possible to add material which will increase the available plant food of the soil; it is also possible, to a certain extent, to alter the physical condition of the soil, as when the addition of lime increases the porosity of a heavy soil. Soil moisture, too, is capable of considerable control; and though this forms a connecting link between the two classes of factors, the fact that it is subject to control justifies its consideration among the latter class. A consideration of the plant in its relation to this class of factor will help us to appreciate the main function of those operations of the cultivator to which we give the general name of cultivation.

The roots of the plant come into intimate contact with the soil particles, and with the film of water surrounding these, by means of the root hairs; it is by means of these hairs that the soil moisture, and with it the salts in solution, are absorbed by the plant. In the process the film of water over the soil particles in direct contact with the root hair is reduced in thickness, and a flow of moisture takes place towards the area occupied by the hair-bearing roots. The larger the amount of moisture in the soil the more readily will a sufficient supply be maintained within reach of the roots. These roots, however,

are carrying on the process of respiration, a combustion of complex organic substances which requires a supply of oxygen. In most cases this is obtained dissolved in the moisture taken in by the roots, and its amount will depend on the area of the film of water exposed to the interstitial air. While, therefore, ahigh water content is desirable, it must not be too high, or the reduction in the volume of interstitial air will lead to a reduction in the amount of oxygen sufficient to interfere with the respiratory processes of the plant, and consequently sufficient to produce a diseased condition. In this respect individual species are very variable; some, as the indigo, being very susceptible to an excess of moisture at the roots; others, as rice, being able to extract sufficient oxygen from the water of a saturated soil. But, in general terms, we may say of most agricultural plants that they require a well-aerated soil with a supply of moisture sufficient to permit a flow to the root hairs as rapid as the rate of absorption by these.

It is the main, but not the only, function of cultivation to supply these conditions, and it follows that the process to be adopted will depend on the climatic conditions of the locality. In one place the rainfall may be such as to produce a saturated condition of the soil, and it will here be necessary to adopt a very different system of cultivation from the one we would adopt in an area where the rainfall was generally deficient. It is not possible to standardise a system of agriculture, and it is most important that we should realise the fact. Scientific agriculture has only recently been introduced into tropical countries, and many of the books on the subject which commonly come into our hands are based on experience gained in temperate climates. These are, in general, countries of moderate rainfall and low temperature, leading to little loss by evaporation; the problem is, consequently, one of removal of excess moisture, and we will find that the question of drainage figures largely in such books. India as a whole is, on the contrary, a country of low rainfall and high temperature, leading to rapid evaporation; the problem here is, usually, how to conserve, and make the most of, the limited supply.

Let us now consider, in the light of the information we have gained, what the effect of the commonest agricultural operation, that of ploughing, is in the direction of favouring plant growth. Before the soil is turned by the plough it is composed of a more or less uniform mass of particles intimately associated with each other, a mass which passes without marked interruption into the subsoil and thence into the rock. Throughout this mass is distributed a continuous film of moisture which may or may not extend to the water table. That continuous film will extend above to cover the particles which are accessible to the free air, and there will take place, consequently, an evaporation of water reducing the thickness of the film and so exerting a pull on the underlying moisture. That evaporation will be greatest in a dry atmosphere, and during the day when the humidity of the air is reduced. During the day, therefore, a reduction of the moisture content of the upper layer of the soil will probably take place, and, according to the physical condition of the sub-soil and underlying rock, to the depth of the water table and to the other factors controlling the rate of motion of water through the soil, the diminution so produced will be more or less completely balanced by an excess of supply over loss during the night.

A condition, however, is conceivable when the loss is too great to be replaced thus, and, in this case, the moisture content will become less and less until the film becomes too thin to admit of the passage of moisture, and the surface soil becomes air-dry. The column of moisture now does not reach within the influence of the atmosphere, and further loss of moisture will practically cease. During the process, however, the soil, the subsoil, and, in cases, even the rock, are depleted of their moisture content to an extent which will provide insufficient moisture for all plants except those whose roots have penetrated deeply.

The essence of the process we have just described lies in the pull exerted by the diminution in the thickness of the water-film covering those particles which come within reach of the atmospheric influence, and on the continuity of this film with that covering the particles more deeply situated. If we break

this continuity, the moisture adhering to the particles lying above the plane of cleavage will dry out rapidly, and the dry layer so formed will prevent the upward motion from below from taking place. Such a break is caused by the plough. If the superficial soil be disturbed, the continuity of the film is broken ; and, if that break be effected before any large loss of moisture by evaporation has taken place, a high percentage of moisture may be retained in the lower soil layers and in the subsoil. In such a case a plant whose roots penetrate into this moist area will obtain an ample supply of moisture, although the surface may appear dried out.

This is a primary function of cultivation, especially in countries, like India, of deficient rainfall. Under suitable conditions, and when effectively carried out, it will limit the loss of soil moisture to little more than that which is taken up by the plant roots, and the period taken in reducing the available supply to below the plant requirements for continuous growth will be prolonged ; in the terms of what we described in an earlier lecture, that continuity in the supply of the raw materials for constructive metabolism which is necessary for healthy growth, is assured by cultivation.

Such is the effect of ploughing, and that effect will be enhanced if the lumps overturned by the plough are reduced to a fine powder, producing what is known as a mulch. Such a mulch acts as a blanket, separating the atmosphere from the moist layers which underlie. But ploughs are rarely used or usable once the crop is sown. Their main use is between the crops when the land is bare. So used, their function is various. Firstly, they break up the soil and leave an uneven surface ; from which surface, flow will be rendered difficult, but a comparatively rapid percolation will take place. Subsequently ploughs are used either to reopen the soil when rain has compacted the surface, or to form a mulch to prevent the absorbed rain from passing off too rapidly, and in this latter case the mulch will be more effective if the surface is reduced to a fine condition by the patha. Their use is not, however, limited to control of the soil moisture ; the opening up of the soil exposes the soil particles of the mass so laid open to the

action of sunlight and air; to those influences, that is, under which the chemical changes involved in the term weathering are most active. The soil, too, may be considered as a medium for bacterial growth and development, and sufficient has been said on the subject of bacterial growth to indicate that what chemical actions these produce in the soil will depend, in large measure, on the degree of aeration and on the amount of moisture, factors which are influenced to a large degree by cultivation.

During the growth of a crop the use of the plough is usually not possible, and cultivation has to be effected by other implements. The basis of the use of these is, however, identical, the formation of a mulch or the absorption of water with the object of providing as constant and even a supply of water to the roots as may be possible.

CHAPTER XV

LIMITING FACTORS AND DISEASE

WE have considered in very brief outline the plant in its relation to its environment, and we have seen that the environment consists of a double set of factors: those which cannot, and those which, to a certain extent at least, can, be controlled by man. Cultivation may in this respect be defined as the acts of man by which he controls the plant's environment, and brings that environment as near as may be possible to the condition most favourable for the plant he wishes to grow. The relation is complex and the number of factors involved difficult to determine. To mention only a few of the more prominent, we have temperature, affecting the entire plant in so far as soil temperature is correlated with air temperature; soil moisture; available mineral and nitrogenous food supply; the physical condition of the soil, all affecting the root; and air humidity and light intensity, affecting the shoot. All these factors, which build up the physical environment of the plant, are simultaneously influencing its development, and it is desirable that we should obtain some idea of the manner in which these combine to produce the visible result of full, or poor, development. We are here merely considering the physical environment of the plant. The full environment includes the influence of neighbouring plants and animals in as far as these develop that competition which we have already noted. Competition with neighbouring plants will affect development merely in so far as it implies a competition between several individuals for the available supply of food material or of energy. It does not affect the method of the reaction, and may, therefore, be disregarded.

We will, perhaps, derive a clear appreciation of this reaction between the plant and its environment by considering a few simple but extreme cases. Let us suppose that we place some seed in a bed ready prepared for the purpose, but, instead of scattering the seed so that each grain comes into close contact with the soil, we enclose the seed in a small tin case. The seed under such conditions will, of course, not germinate. But why will it not do so? The only factor by which the

environment of that closed seed differs from the environment of the seed sown broadcast is that here the moisture in the soil cannot reach the seed. The temperature is right, there is oxygen of the air present, but there is no moisture. Moisture is here the factor which prevents, owing to its absence, the development of the seed, and is what is known as the limiting factor; of all the factors which influence the development of the seed it is the one missing, and, owing to its absence, no development at all is possible.

We may take another sample of seed; for instance, the pea seed; place it in a flask filled with water and leave it at the temperature at which pea seed will germinate rapidly. But under these conditions the seed will only soften and ultimately rot. Again, the temperature is suitable, and there is ample moisture; but, in this case, oxygen, which is supplied to the germinating seed by the air, is not available, as the seeds are immersed. The limiting factor is here the supply of oxygen; and, because this is cut off, development is impossible.

We can take, finally, a third case. We can take two trays of moist sand and in these place pea seeds. One of these trays we can place at a temperature of about 60°F., and the other at a few degrees above freezing. Germination will be rapid in the first case, showing that all factors necessary for plant growth are present; while in the latter no growth at all will take place. Now the only difference here is temperature, which, therefore, constitutes the limiting factor; and, because the temperature is not sufficiently high, no development at all is possible.

We have here three very simple examples of what has come to be termed the action of limiting factors. We must look on the plant's environment as built up of a series of factors, each of which influences plant development independently of the rest. If one only of those factors is absent no development will be possible. The above, however, are only extreme examples. Very frequently all the factors necessary are present, but the amount of some may be insufficient for full development. In such a case the factor which is present in least amount will control the development of the plant, and no excess amount

of any of the remaining factors will assist. Full development will only take place when, at each stage of the plant's development, all the factors which build up its environment are present in sufficient amount.

Such a condition for optimum development is rarely, if ever, attained. The average outturn of wheat in non-irrigated tracts in the United Provinces is 12 maunds per acre, and in the irrigated tracts is 15 maunds; indicating that, at some stage of the wheat plant's growth, water has formed the limiting factor in non-irrigated tracts. Records exist of wheat yields as high as 75 maunds per acre, and where yields fall below such a figure some factor must be acting as a limiting factor to check full development. That factor may be climatic and uncontrollable, in which case the maximum yield will not be attainable; but, if it be controllable, an increase of yield becomes a possibility. We have here another aspect of the cultivator's art; we can consider it as a search for, and, if possible, removal of, the environmental factor which limits growth.

That such a determination will be by no means easy will be made evident by few practical instances. Let us consider the reaction between a plant like the cotton and its environment under the conditions which prevail in the hot weather. During the night, light is absent, and that building up of plant-food which is the product of the energy absorbed by the leaves is impossible. Growth can only take place at the expense of the food material already stored in the plant. Light here is nightly the limiting factor; and, though it is not conceivable in a place like India, any prolonged absence of light would soon lead to the death of the plant. In the morning, as the light develops, assimilation becomes active, the passage of carbon dioxide taking place through the stomata, and food material in the form of starch is rapidly built up; but with the progress of the day, the rise in temperature, accompanied by air motion, causes a loss of moisture through the stomata which becomes more rapid than can be made up by the water taken up by the roots. To check this loss the stomata close, but, in so doing, they cut off the supply of oxygen, and assimilation

is consequently checked. The supply of food necessary for strong growth is thus cut off, in the first place by the supply of moisture acting as a limiting factor; and, subsequently, by the same action on the part of the supply of oxygen. Later in the day the intensity of the sun diminishes, and the stomata reopen, rendering assimilation possible for a short time before darkness again makes the absence of a supply of energy the limiting factor.

This is an example of the action of certain uncontrollable factors of the environment as limiting plant growth. They are not, however, the only factors that act in this manner, and frequently factors which are controllable will be found to be concerned. In the above instance, at one time of the 24 hours, soil-moisture acts as a limiting factor, and soil-moisture we know is, within limits, controllable. Frequently the addition of available plant-food to the soil is responsible for a considerable increase of yield, and in that case the amount of that particular element, nitrogen, phosphorus, or whatever it may be, will constitute the limiting factor. It is the capacity for the quick recognition of the particular factor which is responsible for a limitation of plant growth in each particular case that will form the main characteristic of the successful practical agriculturist.

The effect of high day temperatures in delaying plant growth in the example given was produced, in part, indirectly through the action of soil-moisture as a limiting factor. If we trace the action of soil-moisture in two parallel crops of wheat, one of which is irrigated and the other not, we will see that the effect of irrigation is merely a removal of soil-moisture as a limiting factor, and the consequent fuller development of the irrigated crop. Here the application of a limiting factor produces an effect which is temporary only. On removal of the incidence of that factor, growth, healthy development will follow.

Let us, however, instead of a wheat crop, consider a crop of indigo growing on land liable to floods, and suppose the field to become flooded. This flooding induces a water-logged condition of the soil; that is, induces a reduction of the volume of the interstitial air, and a consequent limitation of the supply

of oxygen to which indigo, with other leguminous plants, is particularly susceptible. The amount of interstitial air in the area occupied by the roots is here the limiting factor, and, unless the amount of water be soon reduced, the plant will shed its leaf and ultimately die. Even if healthy aeration is restored before death supervenes in such a case, the plant may, or may not, recover; it may remain sickly or even ultimately die, although, as stated, the original conditions inducing death have been removed. There is thus a response between the plant and its environment; fluctuations in the latter will produce a response in the former from which a recovery may or may not be possible. According to the nature of that response and the outward appearance of the plant affected, we are accustomed to speak of the plant merely as ill-grown or as diseased.

If we have grasped the essential points of the above facts we will readily understand that the absence of any sharp division where the capacity for recovery ceases, or of any sharp distinction between a state of health and one of disease, are not to be expected, for the physiological condition to which we apply the name disease is seen to be produced by adverse conditions of varying intensity acting throughout an undetermined time. There can be no definite break to the intensity of these conditions. It is the object of the agriculturist to obtain a quick recognition of the adverse factor, and to remedy it before a recognisable state of disease supervenes.

Such disease as we have referred to is physiological; that is, an internal failure of the organism to carry out fully the essential vital functions. But disease may be of another kind. Many crops are attacked by definite fungi, which penetrate into the tissues, or by certain insects which injure the plant in different ways as by eating the foliage or by boring into the stems. In such cases, we are considering the interaction between two organisms; or, in other words, the relation between the plant and the organic section of its environment. In certain cases, as when a flight of locusts descends on a crop, the struggle between the two organisms is too obviously unequal, and the remedy is only to be found in the elimination of the invading

organism ; but in other cases, and this is especially true of fungoid diseases, the fight is by no means so one-sided. In such cases it is very frequently some very minor factor which will decide which organism will triumph. The incidence of wheat rust illustrates this point very well. A slight difference in the level in a field leading to waterlogging in the rains, and consequent destruction of nitrogen owing to the anaerobic conditions locally developed, will result, as the consequence of nitrogen starvation, in a weak plant being incapable of resisting the attacks of the fungus. It cannot be too clearly recognised that these cases of inter-action between two organisms are similar to that of two wrestlers. If one of these, through ill-feeding, ill-living, or ill-training is not in the best of health, he is likely to be beaten. It is the same with the plant. Though no plant will be able to resist a swarm of locusts, there are a very large number of cases, more than is generally supposed, in which disease will only supervene if the conditions of growth do not develop a healthy plant, and in which the remedy is to be sought, not in the removal of the parasite, but in the development of such a healthy condition of the host that it will resist attack.

We have now completed our survey of the foundations on which agricultural practice is laid. For we have learned to recognise a specific optimum and a specific range each of the environmental factors, both of which are characteristic of the plant. We have learned to select our plant on the basis of those specific characteristics so that these come to lie within the range of the uncontrollable factors of the area of cultivation ; and we have learned that we must adapt the controllable factors not merely to come within the specific range, but to approximate to the specific optimum for the plant we are growing.

We have also very briefly reviewed the essential facts underlying and influencing the various factors of the plant's environment. It is the extent to which we appreciate those facts that will determine the degree of our success in our attempts to exercise such control and govern our future as practical agriculturists.

PART III.

THE BASIS OF AGRICULTURAL ECONOMICS

CHAPTER XVI

WEALTH AND VALUE; PRODUCTION AND CONSUMPTION

AGRICULTURE, or the cultivation of the land, is merely one form of human activity, even though our earlier considerations have shown that it is the most fundamental form and earliest to develop in the progress of the human race. It is not possible to consider agriculture as independent of these other forms of human activity. The cultivator grows the crop, and part of the produce goes to feed and clothe the city artisan who obtains the wherewithal to purchase that produce from the proceeds of the sale of goods which are the result of his labour. We have, however, in this brief description, the basis of the entire structure on which the organisation of the human race is founded. We may look at the statement, therefore, more closely.

The essential need of man is food, and for that food the city inhabitant is dependent on the agriculturist situated in the country, for he is unable to produce it in the town. The city man, to speak in the simplest terms, desires food, and, as he is unable to produce that food himself, there arises a need for a supply of food which others have to satisfy. We may ask ourselves why the cultivator bothers to produce more food than he requires for his own use. The answer to this question is that he desires things other than food which he is not able to produce, such as clothes and brass vessels. In both cases we have demonstrated that character which is present in almost every human being, the desire to possess. It is this character,

based on human nature, which has led to that economic development to which we must now direct our study.

That desire, in the cases we have referred to, is a desire for the satisfaction of every elementary want, but it is characteristic of human nature that its desires are never satisfied. The city worker, as soon as he has satisfied his need for food, desires to possess an umbrella or a pair of shoes; the well-to-do lawyer desires to exchange his pony and trap for a motor car, and so on; and we would distinguish between the former and the latter by saying the latter was wealthy or possessed wealth. That leads us to an understanding of the meaning of the word wealth. We may call a man wealthy because he spends a lot of money, when he will at least appear wealthy, or because he is possessed of large estates, or a profitable business, but in these statements we have not the same fundamental meaning of the word wealth that is to be found in the earlier statement. We call such men wealthy because they possess the means to purchase what they desire to own. Wealth, then, is something desirable, something which man in general desires to own.

That, however, is not a complete definition of wealth; a thing, it is true, could not constitute wealth if it were not desirable, but it is equally true that everything desirable is not wealth. The cripple may desire to be an active man, the leper may desire to be permanently cured, but neither have any chance of their desire being realised. To use a word common to both instances, health is desirable, and the same may be said of friendship, but they are both characteristic of the individual, and cannot be obtained from others. We are thus able to define wealth more closely, as desirable things which can be exchanged; and if we consider the instances here used to illustrate our meaning we will notice that those termed wealth are material, while those that were not wealth are not material. It is, in fact, true that most material things constitute wealth, even the dust of the roadway will find someone desirous of possessing it, but it is not equally true that all non-material things are not wealth. As a common instance we may take the case of a doctor's or a lawyer's practice. When a doctor

retires he will find other doctors ready to take his "practice" and to pay a certain sum for what is known as "goodwill." That goodwill is non-material, but it is desirable, and it is exchangeable, and, therefore, constitutes a form of wealth.

That, then, is, in the simplest terms, what wealth is, and it is desirable that we should obtain a clear understanding on this point, for it will enable us to understand much in our study of the economic side of agriculture which will not otherwise be clear. From this definition we may proceed further in our investigation. We have just said that most material things constitute wealth, and have referred to the roadside dust in illustration. In like manner a diamond is a form of wealth, for it is desirable and exchangeable. Diamonds, however, occur in quartz rock, and have to be mined; as long as they are in the ground they are inaccessible, and, therefore, not exchangeable; they are, however, capable of being converted into wealth by the process of extraction from the rock, and by cutting to make them develop those characteristics on which they depend for their desirability. Before removal we may term them potential wealth; and, in like manner, we may term the nitrogen, phosphorus, and other forms of plant food in the cultivator's field, potential wealth; for they are used by the plant to build up the produce which is desired by man, and can be exchanged by the cultivator.

We may proceed along another line of thought. Wealth is desirable, and that desire rests in the mind of a person and makes him anxious to possess. The question as to whether any particular article represents wealth, and, in like manner, as to the amount of wealth that that article represents, will be determined by the presence, and by intensity, of the desire for possession. The measure of that intensity is what is termed the value of the article, and value is thus external to the article. It follows from this that the same article may have a different value at different times or at different places; at different times, because the sum total of the desires of persons to possess will be fairly constant while the amount available will vary at different places, because the desire of the different inhabitants will differ.

We all know that the price of grain goes up in a famine year. The needs of a certain population in respect to grain are definite within fairly sharp limits, for, with the satisfying of the appetite, the desire for food departs; and against this constant desire we have the variable production of a good or bad year. If the season be bad the amount of grain may be insufficient to satisfy the total desire, and those whose desire is greatest will be prepared, in order to satisfy that desire, to part with a larger amount of wealth of another form than usual. We have here an instance of the first class. Of the second we have only to consider the desire that the residents of an arctic climate like Iceland would have for the thin clothing worn by the inhabitants of the tropics.

Value, therefore, is merely the measure of the intensity to possess, but a measure in what standard? It is customary to state the value of an article in rupees, or, to use a common expression, to say the price of the article is so much in rupees If we go to a furniture shop and enquire about a table we will be told the price is, say, ten rupees; if we go to a grain merchant we will be told the price of wheat is 5 seers, meaning that for one rupee we can buy 5 seers of wheat. Similarly, if we wish to get some idea of the extent of a man's wealth we will think of him as being worth so many lakhs of rupees. This reference to a money basis is, however, misleading. In our preliminary survey of our study we defined the function of money, and saw that it was merely a token to facilitate the exchange of wealth. If we possessed the desire for 50 seers of wheat, and if we were to find a man with 50 seers of wheat who desired to possess one table, were the intensity of our mutual desires to be equal, the exchange could take place without the medium of any token. It is important to recognise that the price of any article, as measured in money, is of no fundamental significance. The measure of the value of any article may be given in terms of any other article, as, in the case, the value of the table is expressed in terms of wheat. Value, thus, is a relative term merely, and possesses no absolute standard. The value of a table expressed in wheat will vary in the same manner as we have seen the value of other forms of wealth to vary, for neither

is the intensity of the desire for a table nor for wheat constant.

We are now in a position to go a stage further in our study. We have had occasion to refer to potential wealth, and to the manner in which it is converted into actual wealth. In the case of the diamond, the stone had first to be extracted from the quartz, and subsequently to be cut. The conversion, in this case, takes place in two stages, and these two stages are interdependent. The cutter cannot cut the diamond until it is recovered from the quartz, while the stone is of potential value only until it is cut. The process of recovering the diamond and of its cutting are merely instances of the general method of conversion of potential, into actual, wealth, a process known as production; and the persons who carry out such conversion we may, therefore, term producers. Practically every individual is in some manner, directly or indirectly, a producer, and it would be near the truth to consider this fact as the distinguishing feature between man and other animals. For though birds, for instance, produce nests, such production is very limited, the produce is rarely exchangeable; and in all matters essential to life, production is left to Nature.

The amount of wealth in the world, were this process of production the only one, would necessarily increase enormously. Simultaneously with production a second process is active. To this the name consumption is given, and we must now consider it briefly. Consumption is the reverse of production; that is, it is the destruction of wealth. Wealth being defined as something that satisfies the desire, consumption may be defined as the conversion of something which satisfies a desire into something that does not. The shell that is fired from a gun is wealth developed as the result of innumerable stages of production, for it satisfies the desire, which arises during a state of war, for killing the enemy. As soon as it has been fired and burst, and as soon as the fragments have come to rest, those fragments cease to satisfy that desire, and are, therefore, no longer wealth. We have here an illustration of very rapid consumption of wealth; but consumption is not so rapid in all cases. Our clothes are the work of a series of producers, and,

when new, satisfy our desire for protection, but as they become old they satisfy that desire less and less until we throw them away as valueless. Consumption here, though prolonged, is equally certain.

In what way now does the cultivator fit into the economic scheme we have just described? Let us briefly consider in the terms here defined what it is he does when he grows a crop of wheat. He sows a maund of wheat in a field, and that wheat is wealth, for it possesses a certain value as satisfying a desire. By the labour of cultivation he places the seed under conditions under which it will develop, by absorbing the various food materials, and, in due course, produce say a crop of 12 maunds. He has thus gained eleven maunds of wealth, and he is as certainly a producer as the spinner, the weaver, and the tailor who produced the clothing. He is equally a producer when he grows the cotton which is spun and woven into the cloth. He is also, as are the rest of mankind, a consumer, for he satisfies his appetite with part of the grain he produces, and in that process reduces that grain to a form in which it no longer satisfies any desire of man. In this, however, he merely shares in that process of consumption which is common to the human race, for all persons must eat and clothe themselves. The special economic function of the cultivator is not merely as a producer, but as a producer of the essential needs of the rest of mankind.

CHAPTER XVII

LAND, LABOUR AND CAPITAL

THE economic position of the cultivator is that of a producer; in common with all producers he, by his labour, converts potential wealth into available wealth. In common with other producers, therefore, he must be in a position to carry out that conversion, and we must now devote a short time to the consideration of what those conditions are which are essential to production. We can start with a very simple example and attempt to trace from that these essential conditions.

One of the commonest needs of man is wood with which to light a fire either to cook his food or to warm himself in the cold weather. In villages situated on the edge of the jungle, that wood is obtained by the villagers for the labour of gathering. The dead vegetation is thus potential wealth, which the villager converts into wealth by the mere process of going into the jungle and gathering the wood as it lies. He is, in a small way, producing wealth, and, from this example, it would appear at first sight that the only factor concerned in this conversion is the labour he expends. A little further consideration, however, will show us that this is not so. The raw material must be within reach, and dead wood cannot exist without resting on the ground or hanging to a tree, in which case the tree must occupy a certain area. In addition, therefore, to labour there is a second factor to production which must be present, and that is land. Further, he will collect only sufficient wood to meet his present needs, and when this is burnt he will collect more. He is, therefore, consuming wealth almost as fast as he produces it.

We may now take the case of a town in which the desire for wood as fuel exists. It will here be impossible for each household to depute a member of the family to go into a jungle to gather wood. The collection of fuel will, in this case, tend to develop into the business of a certain class, the members of which will gather wood where it is available and bring it to

the town, where they will sell it, and, with the money so obtained, purchase food. Again, we find the same two factors of production, and if each spends all the money he receives for his wood he will still consume wealth as fast as he produces it. A man so employed, however, will soon find that, if he is possessed of an axe, he will more rapidly be able to collect the same amount of wood, or be able to collect more wood in the same time, and, consequently, to earn more than he needs to supply him with food. In this case there are two additional points to notice; in the first case there is the axe, which constitutes an additional, or third, factor; and there is the fact that production now exceeds consumption, and there is an accumulation of wealth. Let us see if we can obtain some general expression for this third factor. The axe is of assistance to the woodman, and its possession is, therefore, desired by him. He is able to get it if he possesses enough wealth in a form to satisfy the maker of the axe. The axe is, therefore, a form of wealth, and it is a form of wealth to which we give the name Capital.

In this simple example we have illustrated the three essential factors of production, Land, Labour and Capital. Into all forms of production from the simplest, as illustrated above, to the most complex factory, these three factors in different degrees enter. Their main features, therefore, must form the subject of a brief study.

The essential nature of land to the producer is self-evident in the case of the agriculturist. It may not be equally evident in other cases, yet a closer investigation will show that it is essential in these also. Producers, other than cultivators, are mostly congregated in cities, and their products are very diverse. But even the meanest of these requires a spot on which he can carry on his trade. The sweetmeat maker must have a place in which he can cook his sweetmeats; the lohar a place for his forge; and a factory, such as a cotton mill, requires land on which to erect buildings and machinery. We can, in fact, conceive of no production without land, for production is the work of man, and man requires solid land to stand on while he works.

But we have also to consider what land is in the terms of economics and to determine its peculiarities. It is material, and its possession is desired by many; it is, further, transferable, and it therefore constitutes a form of wealth. As a form of wealth the special features are that the quantity is limited, it is immovable, and, consequently, its value is determined not merely by extent, but by its position. The value of agricultural land is further determined by its quality. The truth of these statements is so evident that it is hardly necessary to offer illustrations. Clearly, land above the perennial snow line of the Himalayas will have no agricultural value, and, in like manner, land fifty miles from town and railway will have little value as a site for a factory which requires a large supply of raw material and labour for working. Land is thus a form of wealth to which the producer must go if it is to form a factor of production; whether it will be so used will depend both on the ease with which the other factors of production can be obtained and on the availability of the supply of potential wealth, to which we can give the name of raw material.

We have stated that the value of agricultural land will further depend on quality. By that term we mean the capacity to respond to cultivation and to yield a profitable crop. Now the production of a profitable crop is merely the combination of various organic and inorganic substances of the air and soil, themselves valueless, into the product of the harvest. Quality thus is merely another expression of the availability of potential wealth. Quality will be lacking if any essential raw material be absent, or if they be physically so disposed as to be non-available.

The meaning of Labour, the second factor of production, is apparently simple. In the simplest forms of production it appears as the work done by the sweetmeat maker in mixing the ingredients, in lighting the fire, and, finally, in arranging the cooked material in an attractive shape, or as the work done by the lohar in beating out the shapeless iron into the plough-share. But when we come to consider the more highly organised forms of production the matter is not so simple. Labour is here diverse. A considerable proportion of the persons

engaged in a factory is employed in the manual process of manufacture, but a certain number is engaged in work which employs the brain and not the hands. Of such a nature is the work of organisation, so that each stage of production may proceed at an equal pace, and of the purchase of raw material and of the sale of the finished article. Here the differentiation between the two types of labour is fairly sharp, but it must not be supposed that this distinction is special to organised production; the simple forms of labour in reality merely combine the two types in the same individual. This becomes apparent when we suppose the lohar to attempt the work of the sweetmeat seller. This he is unable to do, not from inability to perform the manual labour involved, but because he does not possess the necessary knowledge; because, in other words, he is unable to perform the brain work required.

We must now consider the essential characteristics of labour as a factor of production, and our first consideration is what induces the individual to exert himself to labour. The answer to this question is that, as a human being, he possesses certain desires which he needs to satisfy, and his only means of satisfying these desires is, by labour, to earn the wealth which will enable him to procure by exchange that which will confer that satisfaction. Labour, again, we have seen to be diverse, and the individual labourer is not capable of taking up any work; the lohar, for instance, is incapable of becoming a sweetmeat maker. The man, therefore, who is compelled to labour to procure the means to satisfy his desire has to search out a locality where there is an opportunity for the disposal of the product of his labour. Labour, unlike land, is mobile; but it is one of the features of labour that its mobility is not complete. The average individual has a love for a certain locality, which he terms his home, or gher, and he will be content to reap a small reward for his labour; in other words, to live with some of his desires only partially satisfied, at home, rather than obtain full satisfaction for those desires elsewhere.

Labour has been referred to above as of two kinds, termed manual and intellectual; with the development of the human race diversity has arisen in the desires of the individual, and

the wealth required to satisfy those desires have become greater in quantity and more diverse in form. The tendency is thus for intellectual work, which receives a larger return of wealth, to replace manual work. In this way our lohar, if sufficiently intelligent and progressive, may gradually set up a small workshop, to the management and supervision of which he will devote more and more time, replacing his own by hired manual labour. He may even replace that manual labour by machinery, or, to speak in general terms, by mechanical power. This replacement of manual labour by mechanical power is a feature of modern development, and has to be taken into consideration in any discussion of labour. Its introduction permits of a development which would be impossible without it, but its importance in the agricultural development of India is as yet small, and we need not do more than refer to its existence.

There remains the third factor of production, Capital, to which we must turn our attention. We have stated that the woodman who employs an axe to assist him in collecting fuel is employing capital, and that that axe is wealth. He became possessed of that axe by purchase ; in other words, he parted with a certain amount of wealth of one form for the possession of wealth in another form which more fully satisfied his particular desire. The wealth with which he parted he must have earned as the result of his labour. In the very simplest terms he must have earned, in the period prior to his possession of the axe, an amount of wealth which exceeded his consumption of wealth by at least the price of the axe. The possession of the axe enables him to gather more wood than he did before, and the extra wealth he may employ in purchasing comforts, such as extra clothing. Or he may save it, as he saved the price of the axe, until he has sufficient to buy, say, a saw.

Let us look at the essential features of this illustration. The axe, which we have stated to be capital, is wealth, but it is a special form of wealth. It is wealth which is employed in the collection of wood, and the collection of wood is, in economic language, the production of more wealth. We have here the essential feature we have been seeking ; and we may define

capital as wealth employed in the production of more wealth. While all capital is wealth, all wealth is not capital. The cultivator produces a crop of wheat, and that wheat we have seen to be wealth. Part of the grain so produced he consumes, and that part is capital, since he would die if he did not eat; the grain is, therefore, used indirectly it is true, in producing more wealth, for by its consumption the cultivator is able to work and produce more wealth. Another part he sells, and with the money purchases jewellery for his wife; this part is not capital, for at most he cannot expect to obtain more than he gave for the jewellery. A third part he stores to sow next season, and this again is capital, for it will next season produce more wealth.

Chapter XVIII

SUPPLY AND DEMAND; MARKETS

We have defined production as the conversion of potential into true wealth, and wealth we have learned to be that which satisfies the desires of man. Production, thus, is not merely the manufacture of a particular article, by which we merely understand the re-arrangement of materials, but the manufacture and supply of that article at a place where there exists a desire which that article satisfies. It is not, for instance, true production to manufacture fur coats in Madras unless the supply of coats so produced can be transported to colder countries where a desire for warm clothing exists. It is not true production to print books in English where a knowledge of English does not exist. Not only is it not true production, it is the reverse; that is, it is consumption, for in the latter case the paper might have been used for printing books in the vernacular. It is impossible, therefore, to consider production as an isolated process. Production is dependent on the existence of a desire for the object produced and the supply of that object to the place where that desire exists.

In the simplest cases of production the producer merely produces to satisfy his own wants; he collects his own firewood and he grows his own food crops. But that simple economic stage has long passed until such production has become the exception. At the present time practically all production is undertaken by the producer, not to satisfy his own desires directly by the product of his labour, but to satisfy the desires of others. Supply, that is, the placing of the produce within reach of the desire to be satisfied, consequently, becomes a matter of considerable importance. The organisation of supply therefore is a matter which we must now consider.

It is not sufficient to arrange for the supply of any particular article at the place where a desire, or, to use a term better suited to the conditions we are discussing, a demand exists for it. It must be within the capacity of those desiring the commodity to produce an amount of wealth which satisfies our

desires more completely than the commodity we have at disposal. We may desire to possess a motor car, and there may be a dealer in motor cars in our locality who is willing and able to supply us with one, but if we have not got the sum he demands for the car our desire must go unsatisfied. Again, we may have the sum he demands, but calculate that, if we expend that sum on the car, we will not have sufficient left to purchase something else we desire to possess. Whether we purchase the car or not will depend, in part at least, on the relative strength of these two desires. This, however, is not the only consideration. There may be another person, also desirous of purchasing a car, and if there is only one car available, the owner will be able to raise the price of that car until it becomes so high that one or other concludes that it is too much to pay for the satisfaction of his desire. Price, thus, is not merely a measure of demand, but of the relation of the demand relative to the available supply.

We have here considered the case where there is only one possessor, who holds the position of producer, and two prospective purchasers, and it is easy to see in such cases how the price comes to be determined. The matter is the same in principle, though not so easily understood when the number of persons holding property for disposal, and of those anxious to purchase, are largely increased. In the former instance there is one desire to sell and two to buy, and the price will be determined by the withdrawal of the weaker desire to purchase. In the same manner, were there two possessors desiring to sell and only one desirous of purchasing, the price will be fixed by the withdrawal of the weaker desire to sell ; in the latter case the price will be lower than in the former. When, however, there are many holders of a commodity and many purchasers there will be a sum of numerous individual desires to buy opposed to a sum of numerous individual desires to sell, and the intensity of these individual desires both to sell and to purchase will differ. This is the case with a commodity such as wheat.

For the moment we may consider ourselves in the position of possessing a stock of wheat of which we desire to dispose. We go to the place where purchasers of wheat are to be met

and make enquiries to find out how much these will pay. In doing so, however, we are constantly reminding ourselves that there are other persons present like ourselves who also desire to dispose of wheat; that, if we do not accept the offer made us, one of these other persons, whose desire to part is greater than our own, will conclude terms with the purchasers, and that, if this happens, we will be unable to dispose of our produce. We have here the conditions which exist in what is known as a market. On the one side is a certain desire to dispose of a given volume of a commodity, which we may term the supply; on the other a certain desire to become possessed of a given volume of the same commodity, which we may term the demand; and the price, which we may term the market price, is fixed by the relation of this supply to demand.

Supply and demand, thus, are each based on a number of individual desires which may vary, and the actual price paid in any particular instance may vary slightly from the market price in accordance with the intensity of the desire for possession. Let us see how this individual desire is controlled. An artisan is accustomed, say, to purchase wheat at 15 seers for the consumption of himself and family, and his daily wants are satisfied with 5 seers. Supposing now the price rises to 10 seers, he will either have to purchase less wheat or spend more money to purchase the amount to which he was accustomed. A conflict of desires thus arises, and, as a general rule, that conflict is decided by a compromise; he purchases less wheat, but spends more than the sum he was accustomed to pay when wheat was 15 seers. Similarly a further rise will result in a still smaller purchase, though at a still larger expenditure. A higher market price, therefore, is normally accompanied by a diminished demand. This, however, affords no explanation of why the price rises; it merely indicates the effect of a rise of price on the demand.

In any given market there is a normal demand, and to meet that demand a supply, which we may term the normal supply, is forthcoming. As long as these remain constant the price at which the commodity changes hands will also remain constant But if anything occurs to alter either the

quantity of the commodity coming into the market, or the quantity required to satisfy the demand, then the price will alter. For instance, the wheat market in any town is supplied by the wheat grown in the surrounding country, and under normal conditions a certain amount will come in on each market day for disposal. But if the crops in the area feeding the market are bad, it follows that, were the same amount as previously to come in daily, the supply would run short before the year was passed. Consequently, less is brought in daily, and the price will rise because the demand remains constant. Similarly we may suppose one of the usual purchasers to take a contract for the supply of a large amount of wheat to a distant place. This purchaser's demand now exceeds the normal, his eagerness to buy will have its effect on the market, and the price will rise. Thus, both increased demand and diminished supply will produce a like result, an increase of price ; while a diminished demand or an increased supply will have the reverse effect of a reduced price.

Let us attempt to define what we mean by a market in the above sense, for it is clearly not what we generally understand by a market—that is a place, or bazaar, where we go to buy our food or our other common requirements. In the first instance, a market is a place where dealings take place in a single commodity ; the market for wheat will differ from the market for other grains. Further, it depends on a multiplicity of desires, both of desires to dispose of and of desires to possess, that commodity, and the price is determined by the interaction of those desires. An auction of property is not a market. It is true there may be here numerous desires to purchase, but there is only one desire to sell, and an increased demand is not accompanied by an increased supply. The essential basis of a market is, thus, that it is a place for the disposal of a particular form of wealth under conditions which admit of free interaction between demand and supply when these are based on a number of independent desires.

Every producer must consider the relation of supply to demand, that is the market, in the particular commodity, which is the product of his industry. He must learn, in other words,

to ascertain and to dispose of his products in those markets where he will obtain the best price. In the language of economics, he must dispose of the wealth which he has produced in the place where the desire for the possession of that form of wealth is greatest. But we have seen that the producer can only carry on his function by the employment of wealth, in the form of land and of capital, the difference between which two forms of wealth lies in the fact that the former is immovable and unproducable, while the latter is both mobile and capable of being produced. There is thus a market for both; but while the market for capital is controlled in manner similar to other markets, by the relation of demand to supply, the market for land is not so controlled; for, while the demand is variable, the supply is unalterable. The price for land is consequently very variable, depending in large measure on the location and the conveniences conferred. The shopman, for instance, requires a site in the bazaar where his shop is readily visited; a site in the midst of fields away from the town would not satisfy his needs; while the reverse is the case with the cultivator, whose greatest desire is for a rich piece of agricultural land.

The price of land as a form of wealth is, thus, dependent on many factors difficult to determine, and it is a complex matter to arrive at the true price of any particular piece of land. In the case of capital the market conditions approximate much more nearly to those of any ordinary commodity such as we have discussed. There is, thus, as definite and determinable a price for capital as there is for wheat, and that price will be controlled by the laws of supply and demand. We must consider what is the price of capital.

In the case of a commodity such as wheat, a certain amount of bargaining will culminate in the transaction being arranged at a certain price, and that price will be calculated in all probability in money. We receive our ten seers, and we pay our rupee, and the transaction is finished. Similarly, in the case of capital, the price is usually fixed in money, but, from the very nature of the transaction, immediate payment is impossible; for, if we possessed the necessary cash, we should have no need to borrow. Payments of loans of wealth, there-

fore, are usually determined by the borrower agreeing to pay, monthly or annually, a certain sum as long as he retains the capital, Such a sum is usually expressed as so much per cent. per annum, 10 per cent. per annum meaning that, for every hundred rupees of the value of the loan, the borrower agrees to pay 10 rupees each year. This sum is known as the interest, and is distinct from the loan itself; that is to say, the loan will never be paid off merely by paying the interest; to complete the transaction the value of the original loan must also be repaid.

Capital, then, is a form of wealth, the price of which is controlled by the laws of supply and demand under the conditions of a market. But such markets exist only in the larger towns, and are represented by the banks. These banks are institutions, one of whose functions is to receive deposits, for which they pay a low rate of interest, and to use the wealth so collected as capital in the form of loans at a higher interest to persons desirous of borrowing. They form a group of lenders, who compete for the disposal of the available wealth among the persons anxious to borrow. The price resulting from this competition is the bank rate, that is, the rate of interest demanded by the bank from the borrower, and, like the price of any other commodity, this will vary.

We have yet to consider labour from the same point of view, for it, too, is an essential to production. As soon as the organisation of production has passed out of the elementary stage the amount of labour required by a producer exceeds the capacity first of himself and then of his family, and he is forced to look round for persons to help him. Such persons he will find willing to work for him if he agrees to pay them a certain wage. Now there will arise competition for the available supply. In the case of labour also, therefore, there is an interaction between demand and supply, and these are each based on a number of independent desires. These are the conditions of a market, and we have thus a labour market in which labour may be considered a commodity differing merely from other commodities in that it has a will of its own. The price of labour is, thus, the wage, and this wage will rise or fall in accordance with the laws of supply and demand.

CHAPTER XIX

THE OWNERSHIP OF LAND

OUR economic study has shown us that the cultivator is a producer, and that the three factors of production are land, labour and capital, the essential features of which factors have been briefly stated. We have now to consider the cultivator in relation to these factors.

In our introductory lectures it was noted that in most countries, and this is true of India in particular, the limited amount of land has passed into the possession of some persons who may be individuals or communities. Any person, therefore, who desires to possess land for whatever purpose must either buy or rent it. In doing so he recognises the right to possession of a previous owner, and when he buys he merely takes possession of those rights for all time in exchange for a certain amount of wealth in another form. When he rents he takes possession of those rights for a limited time only, after which his claim to possession ceases and the land returns to the possession of the previous owner. In the latter case the amount paid in compensation is, naturally, less, and will vary in proportion to the length of time for which possession is taken. In the former case of outright purchase the purchaser becomes a landholder or zemindar; in the latter, a tenant or rayat. The landholder may cultivate the land himself in whole or in part, or he may rent that portion he does not himself desire to cultivate to tenants, and the actual cultivator may thus be either a zemindar or rayat. Whether the landholder cultivates himself or rents his land to tenants depends on many considerations into which we shall have to look later; for the present we may merely note that there are two interests in the land, the one permanent, the other temporary. We have further seen in our preliminary survey that there is a third, and somewhat impersonal, interest, that which is known as the State. Now it is no uncommon feature that, when more than one interest is concerned in any particular object, those interests are apt to

clash, and the interests in land we here see to exist form no exception to the rule. The foundations on which these interests are based, therefore, require investigation.

The interest of the tenant is clear ; he pays a certain sum to the landlord in return for permission to use the land for the production of wealth. The questions as to how much he pays and why he pays it to the landlord, are not so clear. There are, in fact, three aspects of the case which we must now consider.

We must start with a still more fundamental question and ask what justification exists for private ownership in property of any description, for potential wealth or the source of true wealth is the property of no one and the gift of Nature. The initiative to bring about its conversion is, however, individual, but, still more than this, that initiative would not be developed without the stimulus developed by a knowledge that a personal reward will be reaped. It would, however, for instance, be intolerable for a private individual to purchase, say, the entire Cawnpore district and lay it out as a park, permitting no persons to occupy or to cultivate it. We have here the basis of the first, or economic, aspect of land ownership, the strict application of which would abolish private ownership of land and confer the rights of ownership on the State.

This economic aspect, however, disregards the history of the origin of States. In all countries the development of a stable form of government has been gradual, and a period of disturbance has been passed through. Under such conditions the landlord was frequently in the position to protect the cultivator by organising the force necessary for the maintenance of order, and he based his claim for a personal share in the land he protected on these grounds. In many cases, too, the State granted tracts of State-owned land to persons who had rendered conspicuous service in defence against external enemies. Lastly, in younger and thinly populated countries, such as Canada for instance, a population is necessary for development, and is only to be attracted by a grant of land. The economic aspect is therefore practically impossible, however theoretically sound, for it is impossible for a State to

abolish rights which have been allowed to develop and which have received the sanction of the State.

Private ownership of land is, therefore, in most cases a settled policy, and we are led to the second, or English, aspect of land ownership. This, as we have suggested, originated in the grant of land for service rendered to the State, and originally entailed the provision of a certain force and equipment for defence of the State when occasion arose. It is easy to see that, as conditions became more settled, the provision of such a force constituted a rarer and rarer demand until it ultimately ceased to be enforced. The English aspect of land ownership is, thus, absolute possession on the part of the landlord, with the State retaining no rights whatever. The English aspect is, as we have seen, an evolved one, and it has been adopted in countries like America and Canada, although the justification is not here present. It would take us deeper into the history of rural development in England than we are able to penetrate here to consider the advantages and disadvantages of the English policy towards land, and we must pass on to the third aspect, which, as it is the one developed in India, we may term the Indian aspect.

This aspect may be considered to be a compromise between the two we have already discussed. In it the State recognises private ownership in the land, in that the landholder cannot be dispossessed and is free to dispose of those rights to whom he pleases; yet it maintains itself an interest in the land, an interest which, in practice, is represented by the land revenue. The whole problem of land tenure is most complex. As in the case of the English system, it is the outcome of a historical development, and will only be fully understood after a full study, of Indian history. That history, as far as Northern India is concerned, forms a record of a series of empires, the Hindu, the Mohammedan, the Mahratta, and, finally, the British, and each has left its mark, which is traceable in the system of land tenure. It has been the policy of British rule to accept and develop such economic conditions as they found to exist, and it is not surprising, therefore, that different sections of the country are found to differ on the question of land tenure,

for at no time was a single full and undisputed rule established over the entire country. Nor has the British policy itself been consistent in this respect, and attempts have not been wanting to graft the essentials of the English system into that found in existence. The result is that at the present time we find such diverse systems as those found in Agra, in Oudh, and in the eastern districts of the United Provinces along with Bengal, existing side by side.

Nevertheless, in spite of this diversity, these systems all possess certain features in common, one of which is the recognition of the State as part proprietor in the land and the practical demonstration of that recognition in the payment of a land tax. Differences arise mainly in the determination of the amount of that tax and in the degree in which the landlord's discretion in the disposal of that land is circumscribed.

It was part of the system of the Moghul empire to assess the land revenue and to farm out its collection to persons who were permitted to retain all collected above a certain percentage of the assessment as payment for the labour involved. With the decline of the Moghul Empire these collectors, whose posts were largely hereditary, and whose sphere of influence was well defined in many cases, established themselves as independent rulers, claiming a right to be considered the proprietors of those tracts of which they were originally only the official revenue collectors. In the confusion following that decline, and prior to the establishment of British rule, many such claims were established and subsequently recognised by the Government set up by the British. Such cases were, however, fortuitous, the outcome of disturbed conditions.

In this confusion the British failed to distinguish between the true landlord of the Moghuls who paid the land tax and those farmers of the tax who had succeeded in establishing a claim to the lands over which they really exercised only the right of collection. We find consequently in the early days of British rule two conceptions of the landlord. Both recognise his proprietory right to the land, but the one considered him a co-partner with the State liable to pay as well as to retain a fair

share of the profits of development, while the other considered him as a State agent merely entitled to a fair wage for collecting the revenue, but entitled to no share in any increment due to development.

Again, the Government was composed of men brought up to the English conception of land ownership and to the principles underlying that conception. These held that the State had no right to a share in the land. They recognised the indigenous system, but anticipated that by fixing the State's claim once for all at a certain figure, and by, consequently, leaving all the profits of development to accrue to the landlord, a body of progressive landowners would arise and form, as the old yeoman formed in England, a class whose interests were rooted in the soil.

With three fundamentally diverging conceptions of the ownership of land, and with incomplete information as to the real claims advanced, it is not surprising that differences have arisen in the settlements made from time to time, and we can trace the results of this vacillating policy in the divergent systems of land tenure in force at the present day. Chief among these is the Permanent Settlement of Bengal, carried out in 1807 at a time when the English conception of land tenure was held by those in authority. That Settlement has demonstrated the unsoundness of the attempt to introduce the English conception of land tenure, and a permanent settlement has been nowhere introduced since that date. Nor has the first of the three above-quoted conceptions, in which the landlord is considered as a tax gatherer, entitled to no share in any increment in value, been adopted. Under the present arrangements, in all areas outside those permanently settled in 1807, the land of the United Provinces is subjected to a periodical settlement. At such settlements, which occur every thirty years, the position is reviewed and the land holder's assets, that is, his rents and other advantages derived from the lands determined. Of the assets so determined, 50 per cent. is claimed by the State.

The position of land as one of the factors of production, therefore, and in the economic conditions prevalent over the

greater portion of Northern India is as the joint possession of three interests. We may best look on these three interests, the State, the zemindar, and the tenant as co-sharers, for this view will bring out the essential and important facts in connection with land. As in the case of other co-partnerships, the interests are mutual, and the largest return will be forthcoming when that return is shared equitably by the interests concerned. Unless this be so, that partner who receives less than his true share will not trouble to perform his share of the labour, and the common return will consequently be reduced. This fact is based in human nature, and must not be overlooked. For our present study, if we accept the view of co-partnership in land as the correct interpretation of the Indian theory of land ownership, it follows that we must examine how far these three interests, the State, the zemindar, and the tenant, are in position to receive the fair return for the part each plays in the development of the land.

CHAPTER XX

LANDLORD, TENANT AND STATE

WE have already discussed the State's share of the produce of the land and seen that it is fixed at one-half the assets of the landlord. For that return the State provides for the protection against external enemies and for the maintenance of internal order. It is the security so provided, with the accompanying certainty that where a man sows there he will reap, that alone induces the cultivator to raise his crop and the zemindar to develop his estate. The State also provides and maintains the system of records by which rights of ownership are established, and it provides, in the courts, a means of deciding cases in which those rights are in dispute.

The share, represented by the land revenue, which the State receives is thus received in return for very definite and material advantages conferred on the remaining co-partners. In like manner the return which the actual cultivator, whether he be landholder or tenant, receives is the very material benefits conferred, for he is the provider of the labour, both mental and physical, without which the crop could not be raised. The advantages to the co-partnership of the zemindar, solely in his capacity of landholder, are not so readily appreciable, for they are less material. It must, further, be admitted that his rights are based on material benefits conferred under conditions which no longer exist. This change of conditions has led to a transfer of those duties of performance from the landholder to the State, and this transfer has not been accompanied by any corresponding restriction of rights. Although, therefore, the landholder's claim to his share in the return of the co-partnership is not to the same degree based on the magnitude of his share in the work of production, it is based on an equally fundamental law that when

the State has recognised the right to private ownership in land or any other form of property the owner who has taken possession on that understanding cannot be legally dispossessed. The landlord's claim to his share of the return is well founded, therefore, but it is something more. The landlord is in a position to develop his estate. By a progressive policy, such as sinking wells and other steps, of which we will learn more later, he can materially affect the return. The difference is one of degree rather than of kind. Failure of the State to afford protection would mean that the cultivator would not sow, as he would not know if he was going to reap. The withdrawal of the cultivator would mean barren wastes in place of crops. In both cases failure to exercise their portion of the duties of co-partnership means total loss of production, while failure on the part of the landlord to fulfil his, merely means a diminished return.

The economic position of agricultural land as a factor of production is, therefore, that it is under the joint management of three interests, all of which draw a share of the produce. The share drawn should, in theory, be proportional to the importance of the duties which the possession of that share entails. As our discussion in the last paragraph has shown, such division is not practically possible. With changing circumstances the relative importance of different duties changes, while rights which have become established and recognised cannot be legitimately withdrawn even when the duties for which they were originally granted in just payment have ceased to exist. Again we are compelled to make a brief study of the history of the subject if we are to obtain a just appreciation of what constitutes an equitable division of the reward.

It will be sufficient for our purpose if we look back a little more than a century and try to form some idea of the condition of the country at that time. The Moghul Empire was tottering, and the actual control had passed into the hands of those who had been agents of that Empire. The conditions were those which invariably succeed any lengthened period of relaxation of the forces of order—depopulation and impoverish-

ment. Security there is none; even the cultivator who sows his crop does not know that someone stronger than he will not come and reap it. The following is a description by a traveller of that time of his journey from Aligarh to Jalali. To those who know the locality the contrast with the conditions at the present time will be obvious:—

> "The country resumed its desolate appearance. It was a flat waste abandoned entirely to Nature, no sign of human industry being visible. All that broke the uniform surface was a waving line traced faintly in the sand by preceding travellers, who seemed to have followed the footsteps of others as I did theirs. At 5 in the afternoon a village built on a protuberance appeared before us."

Such was the condition of vast tracts of the country when the establishment of British rule once more introduced law and order, and agricultural development could again proceed; and it was under such conditions that the early settlements were effected. The landholder was then in possession of tracts of land on which he was assessed, and he depended on the cultivation of those tracts for the means of meeting the assessment. For this the population was all too inadequate. To speak in economic terms, competition lay between the landholders for the limited labour supply. This was clearly a condition in which the cultivator held the whip hand. Were he dissatisfied with the share of the produce offered to him he could find another employer with ease. There was every reason for a policy of conciliation on the part of the landlord; for, if he established a reputation for harsh treatment, he would fail to get a tenantry. At the same time there was every reason to check the tenant in any tendency to drive a hard bargain, for to do so was to weaken the landlord's power, and it was to the landlord that he looked for protection from the marauding parties still too common. The division of the produce as between landlord and tenant thus came to be equitable. It formed the legitimate reward for the service of protection which he afforded, and it provided the two incentives for the intelligent effort on the part of the tenant, first and primarily the necessity of procuring the essentials to existence, secondarily the means

of satisfying his desire for those non-essential, but desirable, objects to which we may give the name luxuries.

We may call that portion of the produce which the landlord took as his share the rent ; and the rent, therefore, constituted an equitable division. We must remember we are talking of a period when trade was small and the organisation of a currency imperfect. Such payments were usually, therefore, made in kind, that is, by actual division of the produce. Such payment is, theoretically, the most equitable, for both landlord and tenant share equally in any loss due to bad seasons, robberies, and so on, as well as in any gain due to favourable seasons. It is a system known as Batai, and involves division of the crop on the threshing floor. But, while, theoretically, Batai is the most equitable method of division, it is, for many reasons, cumbersome, and, further, it lends itself to abuse under the conditions which subsequently arose. It is, for instance, inapplicable in the case of a crop such as cotton, in which the harvest period extends over several months, for it means holding up the disposal of the earlier pickings until the entire crop is picked or the repeated sub-division of each picking. A variation of the Batai system thus arose in which the standing crop was estimated and the proportion due to the landlord calculated on the basis of that estimate. This system, known as Kankut, is originally less equitable, for it throws the risk of wrong estimation entirely on the tenant. Nevertheless, its advantage to the tenant in avoiding the delay involved in actual weighments is sufficient as long as equality of freedom in estimating the return exists. It is only when such freedom ceases to exist that this method of payment becomes, like Batai, inequitable.

The conditions which we found to exist when the British first developed law and order underwent a change as the result of that development. In the first place, the landholder, no longer carrying out the duty of protector, a duty which has devolved upon the State, has no longer need to propitiate his tenants in order to supply the means of defence of his property. In the second, the removal of strife has given a free field for the rapid multiplication of the population settled on the land.

An ever-increasing body of prospective tenants arose, and competition for land has, thus, developed simultaneously with the liberation of the landlord from the restraining influence of the need for defence. Under such circumstances the inevitable result has been that which we find, an ever-increasing rental until the share left to the tenant is barely sufficient to supply the essential needs of himself and family. Under pressure of this competition even the apparently simple and equitable system of Batai has been twisted to favour the landlord as a study of the additional imposts of kharch dhala, nazar, khakiuna, biaha, wazan kashi and so on would show. Even Kankut came under abuse, for, if the tenant disputed the landlord's estimate of the crop, the latter's agent could postpone his visit until the harvest season was long past and the crop had suffered material damage.

At the present time this competition has developed to a degree which has placed the landlord in a position of undisputed control. He is in a position, if he so desires, to exact from the tenant all but the barest minimum necessary for existence, and to this the tenant must submit, for he has no alternative means of gaining a livelihood. He is, thus, able to extract all the profits out of the land, while at the same time he is being relieved by the State from the necessity of carrying out those duties on the performance of which his claim to a share of the profits was based. The evils of the position are apparent, and the recent tenancy acts are efforts to remedy the defect and to develop a more equitable distribution of the profits of cultivation. The understanding of these acts will be rendered easier if they are read in this light.

Acts, however, are merely palliatives; they may check, but cannot remedy, the evil. That remedy is to be found in a full understanding by all the parties concerned of the position of co-partnership which we have here indicated, and of the consequences that such a recognition involves. The cultivator is the agent who is, in practice, responsible for the production of the crop. We have already learned sufficient to understand that what crop is produced will depend, in large measure, on the skill with which the cultivator adapts the conditions of

growth to the particular needs of the farm and on the amount of labour devoted to the process. That skill and that labour he will not develop if the increased production, which is the result, passes in its entirety to others. To develop that skill and to expend that labour a sufficient portion of that increase must remain in his possession to make it worth his while to do so, and this the present circumstances do not, as a rule, allow. We shall have later to consider the remedy for the evils of the present economic conditions in the control of the factor of land in agricultural practice of the present day.

CHAPTER XXI

AGRICULTURAL LABOUR AND CAPITAL

THE second factor of production is labour, and at the present time the labour required for agricultural purposes in India is almost entirely manual. We may distinguish two kinds of manual labour: that which works and reaps the reward in the product of its own effort; and that which works without personal interest in the result of its effort, but receives compensation in the form of a wage for the effort expended. The mass of agricultural labour is of the former class, and the stimulus which a knowledge that greater effort will lead to greater reward is a strong incentive. It is, however, impossible to dissociate entirely the factors of production the one from the other. Land is a commodity, the price of which is subject to the laws of supply and demand to the extent that the price will rise with an increased demand; but it differs from other commodities in that the supply cannot be increased above a certain definite limit. The increased demand caused by the large increase in the population in India in the last century has practically resulted in the limit of the supply of agricultural land being reached. Consequently the demand arising from the competition of an ever-increasing number of tenants for the available land has resulted in forcing up the price until the entire produce is barely more than sufficient to pay the price demanded. The tenant may work harder and thus produce more, but if he does this he may have to submit to higher rent under threat of eviction.

The above is no pleasant picture of the cultivator's position, nor is it meant to be understood that the entire tenantry of Northern India is in this unenviable position. Nevertheless it is a condition towards which the cultivator is rapidly approaching, and at which, in certain cases, he has already arrived. From the point of view of labour, which we are now considering, it is a deplorable situation; for, although nominally a tenant,

and working in his own interests, his position is nearer that of the hired labourer who works for a wage. He reaps no reward for increased effort, and consequently has no incentive to exert himself. It is immaterial if he produces 15 or 20 maunds of wheat per acre if he is in either case only going to retain 3 maunds.

The hired agricultural labourer receives usually in kind a certain wage, and has thus no interest in the results of his labour and no incentive to increased effort unless personal affection for an old employer or some such interest acts as a motive. We may ask why it is the tenant continues to rent land and cultivate for others to reap the reward of his industry, and why the hired agricultural labourer continues to work on a low wage hardly sufficient to support life. The answer is that man generally, and agriculturists particularly, are slow to change. They know of no alternative work, or, if they know, either from love of their village or from fear of going into the unknown, they prefer to continue in the old life to which they are accustomed. It is this conservatism, characteristic of agricultural labour in all countries, which places agricultural wages on a lower scale than those for any other form of employment. Put in other words, the labour market does not as a whole affect agricultural labour.

From labour we must pass to a consideration of the third item of production, namely, capital in its relation to agriculture. In practically every form of production capital enters to a greater or less extent. The fuel supplier requires his axe and his saw and his scales for weighing out the quantity. Even less capital than this is employed by the city grass-cutter, whose capital is limited to his khurpa and the rope with which he binds the bundle of grass which he carries on his head. These are capital, for they cost a certain amount of wealth, and are used in converting the potential wealth of wood in the jungles, or of grass on waste spaces, into fuel for the consumption of man or fodder for man's cattle. At the other extreme we have production represented by the cotton mills employing large quantities of machinery and requiring extensive buildings in which to house that machinery.

In comparison with the latter example the agricultural requirements of capital are slight, but, nevertheless, important. We may recognise three classes of capital. For the actual work of tillage the cultivator requires certain implements such as his khurpa and his phaora, and it is conceivable that he might carry on the work of cultivation with those alone if his area were sufficiently small. In practice, however, the area of his land is too large to be cultivated by manual labour only, and further implements, the plough and patha, and the necessary power to use these in the shape of bullocks, are forms of capital which are sufficiently desirable to be termed essential. These implements are movable, the property of the actual cultivator, and form, therefore, the first class of capital which can be disposed of or removed at the discretion of the cultivator. There is a further class of property, however, which constitutes capital which is not removable. We may have a field which, under the most favourable conditions, will yield heavy crops, but which is dependent on the natural moisture; and in a season of low rainfall this moisture may be insufficient to admit of the growth of a crop. But if, by the expenditure of a certain amount of money, a pukka well can be built which will control that field, failure of a crop on account of insufficient moisture will be no longer a possibility. The expenditure of the wealth incurred in the construction of that well will be capital, because it is wealth employed to produce more wealth, the wealth actually produced, as the result of that expenditure, being the difference between the produce from the land when irrigated and when unirrigated.

This form of capital differs from the last in much the same manner as we saw land to differ from other forms of wealth. The well is immovable, and depends for its utility in large measure, as we saw in the case of land on its location. It is consequently capital which will only be reasonably expended by a person who has a prolonged tenure of the land. It is essentially expenditure unsuited to the tenant, for, if he is evicted, he cannot remove the well, nor is he in a position to enforce compensation for the expenditure he has increased. As similar examples we may note the levelling of land, and

planting of fruit trees which will only bear after a number of years. Such capital expenditure is legitimate in the case of a landholder whose tenure is sufficiently lengthy to ensure that the return on the expenditure will not pass to others.

Similar in nature, but differing in degree, is the large expenditure incurred in the canal system in Northern India and in the railways, whose main function is the transport of agricultural produce to the markets where it will fetch the highest price. The extent of these systems and the amount of capital required places their production beyond the power even of the landholder whose interest in the land is permanent. They require the intervention of Government for full development.

We come to the third class of capital, a class into the consideration of which we will have to enter in greater detail. If for any reason, illness, unfavourable seasons, festivals or such like, the produce left after the rent is paid is insufficient to feed the cultivator and his dependents until the next crop is reaped, he must borrow the food that is necessary to keep him from starvation till that time. Such food we have seen to be capital, for it is wealth which is used to keep him healthy and strong. Without that health and strength he would be unable to perform the labour which is necessary to the production of the crop. He is, therefore, borrowing capital, but it differs from the former capital in that it is essential. The cultivator can, if need be, sell his cattle and implements; they are essential for the purpose of cultivation, but he can obtain a wage as a hired labourer working for another. But he cannot do without food.

Under such circumstances the cultivator is not a free agent, for he cannot afford to bargain with the person who holds the food. He must either accept the terms offered for the supply of food or starve. These are not the conditions of a market which we have learned to be a place where free interaction can go on between demand and supply. Such free interaction implies a limit beyond which, if the price goes, the demand will cease. But where the desire is for the food required to maintain life, that desire is infinite, and cannot

cease. In these cases there is no automatic control of the price, which is whatever the lender chooses to make it. There is every opportunity for the price of such loans to be very high, and very frequently a very high rate of interest is demanded. The sole controlling consideration is a moral one, the sense that it is not right to make money out of the misfortunes of one's neighbours. This moral check is strong; it receives the support of all religions, and to a certain extent it is maintained in a court of law. Usury, by which name interest on capital passes when the rate of that interest is determined by the necessity of the borrower, is a term of contempt in all countries, and the usurer is everywhere despised. Yet it has to be admitted that its practice is very prevalent wherever conditions place any class of persons in the position of having to borrow the needs for existence.

Capital is thus of importance to agriculture and to the three interests in agricultural development; to Government for the major works, to the landholder for minor works, and to the cultivator, be he tenant or petty-holder, for the carrying out of the actual process of cultivation. In all except the latter the conditions are, from the borrower's point of view, those of a market; there is a demand which will, and can, remain unsatisfied if the price demanded is too high. In the latter case only is the market condition not present. We must look at this latter demand more closely; we have seen wherein the demand lies, but have not yet studied the supply.

For a cultivator out in a village it is clearly an impossibility to go into the larger cities in which we found the market for capital to exist. He requires small loans readily transacted, and also he requires the transaction to be made in kind. These factors we will have to go into more fully later, for the present it is sufficient to note that the need for capital in the village is supplied by the village money-lender. This agent performs a most useful function; if a cultivator's cattle die he will advance the capital necessary on terms which will be convenient to the borrower as to the method of repayment. Payment may be arranged, for instance, in terms of wheat payable at the next harvest. If a loan is required against a marriage ceremony

there is the same ease of borrowing and the same facility of method of repayment. Our discussion of the present economic position has, however, shown us that the position of the cultivator has, owing to the competition that has arisen for land, become precarious. Rents have risen till the major portion of the produce of the tenant is absorbed in satisfying the landlord, and little margin remains for saving after the essential needs are satisfied. Frequently even those needs are not satisfied. Borrowing of the grain required to sow the crop is frequent because that which should have been saved for the purpose has been absorbed in the provision of necessaries. Even borrowing of the food required to support life until the next harvest is frequently necessary. These loans the village lender, who also functions as general trader, will make, but he is in the position of trading on the necessities of others. Such a position need not, but frequently does, lead to usury.

In the village money-lender, therefore, we have a fourth interest, and a very important, if not direct, interest in the land. He fills a very important and essential place in the agricultural economy of the present day, and, if he is in a position to abuse that position and to practice usury, it is a comparatively recent development, not the result of the conscious effort of the money-lender himself, but of the material development due to the increase in the agricultural population working through the competition for land and increased rents.

We may sum up the present agricultural situation as one in which four interests are concerned, all of which will benefit by agricultural development. The basis of that development is the production of larger returns from the cultivated area, and this is dependent for realisation in practice on the man who actually tills the soil, in other words, the cultivator. The economic conditions, however, are such that the cultivator will reap but a small, if any, portion of the fruits of his enterprise, and we cannot be surprised if under such circumstances he fails to develop that enterprise. It will be our business in a later section to see how this unsatisfactory state of affairs is to be remedied.

PART IV.

THE DEVELOPMENT OF AGRICULTURAL PRACTICE

CHAPTER XXII

THE CROP

IN the preceding sections we have considered the present position of agriculture in India, the main facts on which the practice of agriculture is based, and the economic conditions under which that practice is carried on at the present time. From the direction in which we approached our subject we learned that the present position has been arrived at by a process of evolution. There is no reason for assuming that evolution has ceased and that practice and the economic conditions have become stationary. There is, on the contrary, very good reason for believing that evolution in both directions will proceed at an increased pace and will be brought about by the same causes as have acted in the past—pressure in the direction of increased production, caused by the increase in population, and the changed relative value of produce, the result of increased facilities of transport. The difference between this evolution in the past and that of the future lies in the fact that the former has largely been based on chance, and we may, therefore, apply to it the name undirected, while the latter will be directed. Recent study and recent experience have thrown considerable light on the relation between cause and effect both in the practice and in the economy of agriculture. Recent scientific progress has made it possible to trace the cause of failures in practice, and has provided a basis for drawing conclusions which can be subjected to practical trial; while recent economic study has produced a like result in laying bare the weak points in the economic organisation. The race is to the strong, and the man who has secured the clearest perception of the forces which make for progress will be the one who will succeed in securing the first fruits of progress.

Let us look at the problem from the cultivator's point of view, for he is the real producer. Provided he is in a position to reap the reward of his labour, a statement which implies that a sufficient proportion of the fruits of his extra labour will remain with him, and, thus provide the stimulus necessary to develop that extra labour, his object will be to obtain the largest money return from his holding. That return, however, is not the absolute value of the crop produced; it is the actual value received for the produce less the cost of production. A crop of cane may, for instance, sell for Rs. 700 per acre, a sum far in excess of the amount realised for a dofasli crop of maize followed by wheat, which we may estimate at Rs. 150 per acre. But if that cane crop involves an expenditure of Rs. 625 per acre, while the dofasli crop involves only an expenditure of Rs. 50, it will pay the cultivator to grow maize and wheat instead of sugar cane for, in the former case, his nett profit will be Rs. 100, while in the latter this will only amount to Rs. 75.

We can distinguish two methods in which the cultivator's object may be attained. The first of these we may term improved production. If, by greater skill, the outcome of better knowledge, he can raise the average outturn derived from his fields without producing a corresponding increase in the cost of production, he will undoubtedly derive the benefit. This improvement is quantitative. Instead of producing an average of, for instance, twelve maunds of wheat he now produces fifteen maunds for the same cost, and he benefits to the extent of the value of the extra three maunds. This, however, is not the only form of improved production. He may, to illustrate the point again with a reference to wheat, substitute for a mixed crop of red and white wheat, by the elimination of the red grains from his seed, a pure white wheat for which he will obtain a higher price. He obtains, for the same cost, the same yield, but, owing to the improved quality of his produce, he reaps a larger money return. Such improvement is qualitative. Nor does this complete the list of methods coming under the head of improved production. By careful cultivation he may so raise the quality of his land, that, from

poor condition, in which only a crop such as bajra will grow, it will produce a crop of, let us say, maize. If, now, the excess value of the maize crop over the bajra is greater than the cost of the additional expenditure incurred, he will again benefit.

The above, which we have termed methods of improved production, are all based on agricultural practice, and we shall now have to study them in greater detail. Before doing so, however, we must glance at the second way in which the same result may be attained. We may term this improved disposal of produce. If we do not consider the individual, but consider the country as a whole, the increase of the value of the agricultural produce, both by the extension of cultivation and by the raising of the value of the return per acre, is most desirable. The greater wealth so derived can be employed in the more complete satisfaction of the needs and desires of the inhabitants either directly, by local consumption of the extra produce raised, or, indirectly, by the disposal of that extra produce and by the acceptance in exchange of those goods which will more fully satisfy the needs of the population. To meet the latter condition it is necessary to study the markets and to find out where, and in what manner, the greatest value will be obtainable. The entire population is concerned, therefore, to see that production is developed to the fullest extent, for it is only so that wealth can accumulate ; but it is also concerned to see that the producer receives a sufficient portion of that extra wealth to supply him with an incentive to make the effort.

In the present section we will deal with the practical aspect from the point of view of the actual producer or cultivator, and we may set out by asking ourselves the two questions the cultivator has to answer when he considers what he will do, namely, what crop shall I grow and how shall I grow it ? From our previous discussion we can understand that the manner in which he answers the former question will be determined by those conditions of environment which he is unable to control, while the manner in which he answers the latter will depend on his knowledge of the conditions the plant requires for full development and on his skill in controlling those conditions of the environment which are controllable.

He cannot, for instance, if he is a resident of the Cawnpore district, when answering the first question, decide to grow spices; for spices require a more humid climate than is characteristic of Cawnpore. Nor can he decide to grow rice if his holding consists of high and unirrigated land. He is, thus, limited in his selection of crop to one which will grow under the conditions of climate and soil of the locality.

Having answered the first question, and that answer will only be satisfactorily given as the result of experience, our cultivator has now to turn to the second. Here two factors are concerned, the crop and the environment, and we must consider these two separately, for, until he has studied his crop and learned what are its particular needs for healthy development, he will have nothing to guide him in controlling the conditions of growth and in approximating these to the optimum.

The crop is a term used to describe a group of similar plants growing together in a particular area. If we walk into the fields and ask any cultivator what he is growing in any particular field he will answer wheat, or cotton, or whatever it may happen to be. The cotton plants, or the wheat plants, are similar, and we may, therefore, speak of them as a crop. But are they, in reality, similar? Similarity is a relative term, and whether we consider two things similar or not will depend on how closely we look at, and try to compare, them. If we compare two wheat plants we can say that they both have narrow, parallel veined, leaves; that they develop as rosettes and subsequently "ear out"; that the ears bear flowers at their upper extremities, and that these flowers ripen off to give the characteristic wheat grain. To this extent these two plants are similar, and the characters here mentioned are the ones that give the character to the crop. But if we examine the plants in a wheat field more minutely, we will observe other characters in which these plants differ from each other. Thus we find certain plants develop awns, the plants then being termed bearded, while others are beardless; the chaff of some turns red on ripening, while in others it does not; or, again, in some the grain is red, while in others it is white. These

differences are sharp and easily determined, and will be found as characteristic of the plant that bears them as are the major characters which distinguish the wheat plant generally. By this statement we must understand that such characters are inherited and pass from parent to offspring ; for, just as a grain of wheat, which is derived from a wheat plant, will develop into a wheat plant only, so will a bald, red-chaffed, white-grained, wheat develop into a bald, red-chaffed, white-grained, wheat only. We must distinguish, therefore, between a wheat crop, which term can be correctly applied to a mixture of wheats, whether bald and bearded, white-chaffed and red-chaffed, white-grained and red-grained, and a group of plants which agree with each other even in these minor characters. We may express this distinction by saying that the wheat crop is composed of a number of varieties which may be further sub-divided, by taking into account differences of still smaller magnitude, into a number of races.

Such characters as we have considered are definite and readily determined. It is easy to say whether a grain is red or white, and whether an ear is bearded or bald. But individual wheat plants will be found to differ in other respects also and in characters which are not so readily determined. In fact many of these characters are not recognisable in the individual plant, and it is only when a small area is sown with seed derived from a single parent, when what is termed a single plant culture is made, that the character becomes apparent. Among such characters we may note strength of straw ; time of ripening, distinguishing between early and late races ; resistance to rust and colour of leaf, while many others exist which are still more indefinite. The varieties and races of wheat, as determined by the more readily recognisable characters, are consequently divisible into still more minute groups to which we may apply the term type. Inasmuch as many of the characters which distinguish these ultimate groups are physiological in their nature, we may term some of these types physiological races.

From the few examples we have given of the distinctive characters of physiological races we are able to draw the correct

conclusion that characters of this nature, though difficult to determine by eye, are of considerable, if not of major, agricultural importance. The eared wheats are frequently preferred to bald wheats, because they are less subject to the attacks of birds and animals; a white-grained wheat is preferred, other things being equal, to a red-grained wheat, because the flour from the white-grained wheat is given a preference which places the price paid for white wheats slightly higher than that given for red. Such differences, however, have a relatively small importance; a little more labour expended in chowkidari will remove loss from the first cause, while the difference between the price of red and white wheat is approximately only four annas a maund, representing Rs. 4 per acre on a crop of 16 maunds. If rain is received after the crop has eared out a strong-strawed wheat will often remain erect when a weak-strawed one will lodge badly. An early arrival of the hot winds will frequently wither up the entire plant, if this is a late ripener, before the grain has swelled out, and in this case all that will be harvested will be a weight of shrivelled grain which may be less than half that of the plump grains obtained from a crop of early ripening wheat. Differences due to such physiological characters may thus amount to many maunds of a value of many rupees per acre.

The crop, then, using the word in the narrow sense and excluding what are known as mixed crops, the intermingled growth of such widely divergent species as jowar and arhar, or as peas and barley, is not uniform, but made up of a number of races which may be large, and a still larger number of physiological races and types. Such a crop will yield, on the average, a certain weight of produce. From that crop we are able to select out, and grow separately, a number of races or types each of which bears some distinctive character or characters, and some of those characters will be physiological, that is, will be indicated by the nature of the response to environment. We will understand that if we now effect such a separation of types and multiply the grain of these up separately until we have enough of each to sow an acre, the yields of each one of these will not equal the average. Some

will give more and some less in such a manner that the sum of each of these, after division by the fraction which represents the proportion of the type in the mixed crop, will give the average. Clearly a direct and immediate increase of yield will be the result of such selection if, in future years, we use for seed purposes only those types which give the highest yields.

We have here, in selection, a ready means of improvement. That improvement may be in out-turn as in the case just described, or it may be in quality, as when the white-grained wheats are selected from the mixture of red and white grains. The improvement finds its basis in the fact that the characters by which one type differs from another are handed down from the parent to the offspring.

Chapter XXIII

SELECTION

In our last chapter we have referred to selection as a means of increasing the yield, or improving the quality, of a crop. The method is based on the fact that the return from a mixed crop is an average of the returns from the individual types. Some of these will give a return above, while others will give a return below, that average and the improvement consists in the selection of those types of which the return is above the average. The method is not, however, quite so simple as we might suppose, and we must look at the question a little more closely.

If we go into a field of wheat just before harvest, select single plants which appear to differ from each other in certain characters, and sow the grain of each of these separately, we will obtain a number of small plots of wheat, the plants in each of which will resemble each other, but differ from the plants in the remaining plots by those characters in which we noted a difference in the plants we selected. In each case the parental character is repeated in the offspring. If we now repeat the experiment with cotton we will find that this is not so. The parent may have, for instance, a yellow flower, yet we may find a considerable number of white flowered plants among the offspring. Or the parent may have a white flower and yet a few yellow flowered plants will be found. And if we observe other characters, such as the shape of the leaf or method of branching, the same failure of all the offspring to agree with the parent will be observed. Here, apparently, the inheritance of the characters of the parent by the offspring does not occur, or, at least, is not the invariable rule. Why is it that what we find to be the case for wheat does not hold in the case of cotton? The understanding of the explanation is important,

since the method of selection which we have described for the improvement of crops depends on that similarity between parent and offspring.

Let us call to mind the elementary facts of the development of the flower and seed. The essential organs of the flower are the stamens and the ovary. Within the anthers of the former are the pollen grains, and these are liberated on the rupture of the anthers. The ovary contains the ovules from which develop the seeds, and this ovary bears a style ending in a stigma. At a certain stage in the development of the flower the stigma becomes "receptive," and the liberated pollen grains adhere to it owing to the secretion of a sugary substance which is characteristic of the receptive condition. The pollen grain then puts out a tube which passes down the style until the tip of the tube reaches an ovule and a nucleus passes from the pollen grain to unite with the nucleus of the ovule to form what is known as the ovum. This fusion of the two nuclei constitutes the act of fertilisation. The fertilised ovum now surrounds itself with a cell wall, and from that cell the young plant develops within the ovule, which later develops into the seed. If we assume that it is the nucleus which transmits the characters of the plant, it must follow that the young plant is dual in its nature, deriving its characters from both the pollen and the seed parent. If, now, the pollen and the ovule are derived from the same plant, if, that is, the seed parent is self-fertilised, the same characters will be transmitted to the offspring through both nuclei, and the offspring will resemble the parent in all respects. But if the pollen is derived from a plant other than that on which the seed is borne, if, that is, the seed parent is cross-fertilised, the offspring may develop characters which were present in the pollen parent but absent from the seed parent. In such a case, as it is only the seed parent which is known, it is not difficult to understand how offspring come to differ from the parent from which the seed is gathered.

We have here the explanation of the difference we have observed between wheat and cotton. If we examine the flower of the wheat plant carefully we will find that the stamens

rupture, shedding their pollen, and that the stigma becomes receptive before the flower opens. Fertilisation is here effected by pollen from the same flower from which the wheat grain is developed, and both pollen and ovule are thus derived from the same plant. In the cotton plant, on the other hand, the flower opens before either the stamens rupture or the stigma becomes receptive. The open flower is visited by insects, and pollen derived from flowers previously visited may be carried and deposited on the stigma of the flower before its own pollen is shed. A considerable number of cotton plants thus arise from seed developed from ovules which have been fertilised by the pollen of a different plant.

If this difference be understood, not only will the cause of the observed difference between the cotton plant and its offspring be comprehended, but a means of obtaining similarity between these, a means of establishing what is known as purity, in such cases will become apparent. Means must be taken to ensure that foreign pollen does not reach the stigma and that the flower is fertilised by its own pollen only. If such precautions be adopted it will be possible to isolate races of cotton in which all the offspring bear the same degree of similarity to their parent as was found in the case of wheat.

Before we commence selection with the object of replacing the mixed types of the field by a pure type, the result of that selection, we must, to ensure success, study the methods of pollination in the particular plant with which we are concerned. If we find that the plant is normally self-fertilised, the process of selection will be simple, so simple, in fact, that the ordinary cultivator could carry it out. When cross-fertilisation is the rule, the process requires greater powers of observation and a larger amount of equipment than are at the disposal of everyone. We have taken cotton as an instance in which cross-fertilisation is effected by insects. Any means, such as covering the flower or plant with a net sufficiently fine to exclude insects will here ensure self-fertilisation. A few other cases, given in order of complexity, may be added to illustrate the way in which the method must be adapted to the observed process of pollination.

In the poppy the pollen is light, abundant and readily carried by wind. The petals open widely and the flower is then wind-fertilised. Protection has here to be provided to exclude not only insects but pollen grains carried by the wind, and paper bags or the very finest muslin must be placed over the flowers. In maize, not only is the pollen wind-borne, but the male and female flowers are produced on different portions of the stem. Here not only must the female inflorescence be protected, but the pollen of the male flower must be collected and artificially applied to the stigmatic surfaces of the styles of the female flowers. Again, we have the case in which the male and female flowers are borne on different plants, as in the date and the papaya. Here self-fertilisation is impossible, and the establishment of pure races, in the sense in which we have used the expression above, is also not possible. The same will be the case with those plants, many of which are known, especially in horticulture, which, though the flowers are hermaphrodite, illustrate a condition known as self-sterility. The pollen of one plant is here incapable of fertilising the ovules of the same plant. The above illustrate merely the main differences which exist between plants in this respect. Each species, and sometimes each race of a species, possesses its own peculiarity in this matter, and actual study is required in each case before a suitable method can be decided on.

The primary stage in selection, thus, consists in the isolation, by means of single plant cultures, of pure types of the crop, and to these pure types the art of selection is applied. The progeny of a single plant is, however, limited to a few individuals, at most, a few hundreds or a few thousands. It is necessary to multiply up a supply of seed, therefore, until a sufficient amount of it is available for sowing on an extended scale. This is a matter of time; but during the process we must continue to pay regard to the method of fertilisation. In a crop like wheat, where self-fertilisation is the rule, the matter is comparatively simple. It is merely necessary to take precautions against accidental admixture during the harvesting operations to ensure purity. But even this is not as simple as it may appear; stray grains of other races may be accidentally

introduced and lead to impurity. A further precaution consequently, is desirable, and the crop should be rogued. Before harvest the field must be systematically examined, and every plant which appears to differ from the type—and such plants are known as rogues—eliminated.

Where cross-fertilisation is common or the rule, the process is not so simple. It is necessary to protect a large number of plants, and this can only be accomplished where the facilities given by a plant-breeding station are available. Even here a stage is soon reached where the crop is of a magnitude to render more extended protection impossible. It is now necessary to bear in mind the facts that we have learned with reference to the method of pollination and to take precautions accordingly. When pollination is effected by insects, the particular insect and its power of flight must be noted. Isolation of the pure crop so that its nearest neighbour is beyond the normal flight of the insect concerned, interculture with another crop flowering at the same season and visited by the same insect and such like methods suggest themselves, and are, in practice, when accompanied by roguing, effective. A sufficient, though not absolute, purity can be maintained by such means. Where the pollen is light and wind-borne, an even greater distance must be allowed between a pure culture and its nearest neighbour.

We must now look at this question, which is, in reality, one of the substitution of pure races for the mixed cultures of the field, from another aspect. We have stated that the outturn of a crop of mixed races is an average of the outturns of the individual races when due allowance is made for the proportion in which those races occur. Each race responds differently to the environment, and the higher yield of one will, no doubt, be due in large measure to the fact that it is the one most closely adapted to the environment in which the test is made. But what are we to understand by the word environment? It is the sum total of those conditions incident partly to the climate, partly to the soil, and partly to the method of cultivation, which affect the growth of the plant. Two conclusions follow from this, and they add complexity to the problem. In

a single locality climatic conditions are inconstant; they may, indeed, vary very considerably from year to year. Again, climatic conditions, and also soil composition and texture, vary from locality to locality. We may consider these two cases separately.

The divergence between the climatic conditions of a given locality from one season to another may be such that the race which gives the best result one season may very probably give very inferior results the next. It then becomes a matter of very considerable difficulty to decide which race is best suited to the locality. It is here a question not of the average season, but of the season which is of most common occurrence, a determination not readily made. We cannot rely on the comparative figures arrived at in a single season, for that season may be an exceptional one, and we can only arrive at an ultimate decision after repetition, over a series of years, of the comparative trials.

It is such climatic variations that lead in many cases to divergence of opinion as to the value of crops derived from pure races. Where the normal variation is large, differences in total yield from year to year must be greater for a pure crop than for a mixed one, for, in the latter case, the failure of one element will, in part, be compensated by the success of another. The custom of growing mixed races thus becomes a system of averaging out the yield. A moderate yield is thereby guaranteed, and, if abnormally high yields are not obtainable, neither are abnormally low ones. The latter consideration is of considerable economic importance in a country in which the average cultivator possesses little capital with which to tide over a period of adversity. There is little doubt that the true mixed cropping systems, the mixed rabi crops wheat, barley, gram, and possibly others as well, found in Bundelkhand, and the jowar, cotton, arhar mixture of the Eastern Districts of the United Provinces, owe their popularity to the insurance against total loss of crop which these mixtures offer. Such insurance is especially valuable in the tracts named, for in them the majority of the agricultural population are, to a greater degree than elsewhere, ill-equipped to tide over a season of crop failure.

In like manner it is not possible, from comparative trials in one locality, to draw any definite conclusions with regard to another. Ceirtainty can only be attained by a repitition of the trials in the new locality. It is true that experience and a knowledge of the local conditions of the different localities will afford some justification for anticipating the probable result; but that probability does not amount to certainty. For instance, we have the wheats known as Pusa 4, Cawnpore 13, Pusa 12 and Mozaffarnagar, here arranged in order of the length of their growing period. We have, similarly, in Bundelkhand, East United Provinces, Central United Provinces and Western United Provinces, four tracts arranged in order of the length of their cold weather during which the wheat grows. From our knowledge of the racial characteristics of these wheats and from our knowledge of the climatic conditions of these tracts, we might reasonably anticipate, as we actually do find, a difference in the order of suitability of these wheats when grown in the different tracts. Pusa 4, having the shortest period of growth, is most suited to Bundelkhand. In the east of the United Provinces Pusa 4 again gives the best results to be replaced by Cawnpore 13 and Pusa 12 in the Central United Provinces; while in the West, Mozaffarnagar remains the most favoured one. The full value of selection thus is to be obtained not only as the result of careful observation of the plant, but of the environment under which growth will take place.

Chapter XXIV

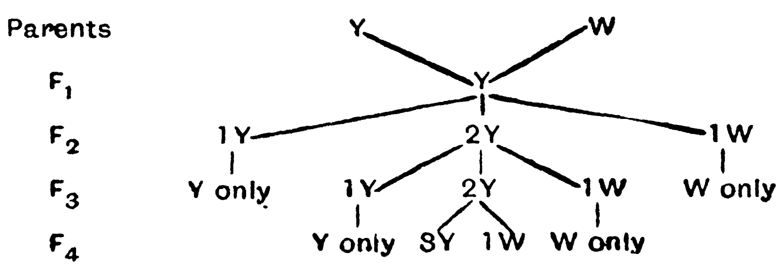
HYBRIDISATION, SPORTS AND ACCLIMATISATION

We have seen how it is possible, by isolation of pure races, or types, from a mixed crop, to obtain improvement of either yield or quality. The essential fact is that we are merely selecting out something that exists already. It is not possible to produce by such means a type that does not previously exist. It is, however, conceivable that we may by this means select two types, one of which possesses one desirable character, while the other possesses another, but that we are unable to find a single plant in which both desirable characters occur. The problem that occurs to our minds is this: is it possible, under such circumstances, to produce such a plant? If, for instance, we have an early ripening red-grained wheat and a late ripening white-grained wheat, but no early ripening white-grained form, is it possible to produce such an one? Let us start with a simple case, and for the purpose we will use to illustrate our description clearly defined characters which have no economic value.

In the cottons we have two flower colours commonly appearing; in one the petal is white, while in the other the petal is yellow. By taking the necessary precautions it is a simple matter to obtain types pure to the yellow colour and others pure to the white. Suppose, now, instead of allowing the yellow-flowered plant to be fertilised by its own pollen, we deliberately fertilise this by pollen of the white-flowered plant and grow the seed so derived. We will find that all the offspring are yellow-flowered. Or we may reverse the process and fertilise the flower of the white-flowered plant by pollen of the

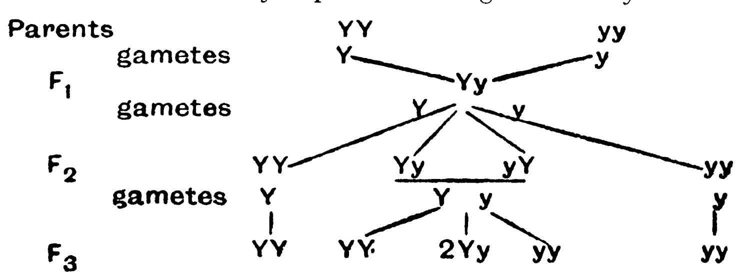
yellow-flowered plant, and grow the seed. Again, the offspring will be found to be all yellow-flowered. In this latter case the yellow petalled character is clearly derived from the pollen parent. Now suppose we allow these offspring, which form what is known as the F_1 generation, to be self-fertilised. From the seed so obtained we will obtain an F_2 generation containing both white and yellow-flowered plants, and, if we count the number of these, we will find that there are approximately three times as many yellow-flowered plants as there are whites. And this result will be obtained, whichever way we make the cross; that is, whether the pollen of the white-flowered plant is used to fertilise the yellow, or the reverse. It follows from this fact that the flower colour-character is transmitted equally from the male as from the female parent.

If, now, we allow these white-flowered F_2 plants to be self-fertilised, we will find white-flowered plants only among the offspring; but when we repeat the experiment with the yellow flowered F_2 plants we find some give yellow-flowered offspring only, while others give yellow and white-flowered plants in the proportion of 3 : 1. If sufficient yellow-flowered plants have been self-fertilised, we will further find that for every plant giving yellow-flowered offspring only, there occur two which give a mixture of yellow and white-flowered plants. We may summarise this as follows:—

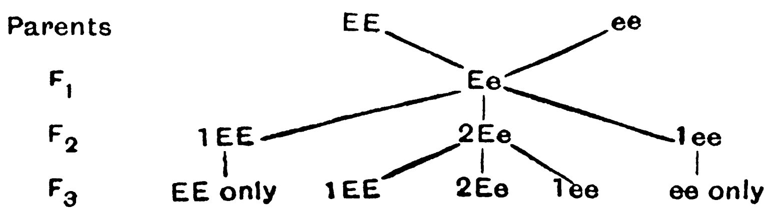


We have here combined the Y and W characters into one plant, which is, therefore, impure for flower colour, but we have also reproduced from that impure condition both yellow and white-flowered plants in a condition of purity. We may express these facts in another manner.

In the above example the yellow-flowered parent possesses a something, which we will call a factor, which develops a yellow colour in the petal, and which is handed on, through the generative nuclei, to the offspring. We may term this factor Y and the absence of this factor y. In the plant pure for this factor the something which we have termed Y is received from both parents, and we can, therefore, represent the condition of purity as YY. In like manner, the pure white-flowered plant may be represented by the formula yy. The ovum which results from the cross between these two plants receives the factor Y from one parent only, and we can, therefore, represent the condition of impurity by the formula Yy. We are now in a position to understand how the proportion of one pure yellow, two impure yellows, and one white arises in the offspring of the plant represented by the formula Yy. Being impure, it will develop gametes, some of which carry the factor Y, and some of which do not, and may, therefore, be represented by y. In the absence of any reason for a contrary assumption, we may suppose that the proportion in which these two forms of gametes are produced is 1 : 1, that is, each class of gamete will occur in equal numbers. Of the egg cells produced, half will thus carry the factor Y, while half will lack that factor. The same will be true of the pollen grains. Further, from the facts of fertilisation, we see that it is purely a matter of chance which ovum is fertilised by which pollen grain and, therefore, the number of unions taking place between gametes of different constitution will be the same as the number of unions taking place between gametes of like constitution. Of these latter, half will be unions between gametes, both of which carry the factor Y; and half between gametes which do not carry that factor. We may express this diagramatically as follows :



Let us now take another character of the cotton plant, namely, the red spot, or eye, which occurs at the base of the petal. In certain races this spot is absent. If we cross an eyed form by an eyeless form, we find that the F_1 plant is eyed and indistinguishable from the pure-eyed parent. In the F_2 we obtain three eyed plants to each eyeless plant raised, and further experiment proves that one of these three-eyed plants is pure, while the remaining two are impure, giving both eyed and eyeless offspring. The case is exactly similar to the one already described for the petal colour. If we term the factor that develops the eye colour E, the pure eyed form may be represented as EE, and the pure eyeless form as ee, and we obtain :—



In both these cases it is not possible to distinguish the pure form from the impure form which develops the colour. We express this fact by saying that the factor for the development of the colour is, in each case, dominant. The fact of dominance is not a necessary condition, and in many instances it is possible to distinguish the impure from both the pure forms. For instance, when we cross a red-flowered cotton by a yellow-flowered one, the impure form has a distinctly lighter shade of red, which cannot be confused with the pure red-flowered parent.

So far we have merely succeeded in reproducing, in a state of purity, the two forms with which we started. This is so because we have so far dealt with plants which differ in one character only. Let us now consider the case of plants which differ in respect to two characters. Suppose, for instance, we possess a yellow eyeless, and a white eyed, cotton. Is it

possible to produce a pure eyeless white form? Diagrammatising as before to illustrate the result of effecting a cross between these two :—

Parents YYee yyEE
gametes Ye yE
F_1 YyEe
YE Ye yE ye

F_2 YYEE, YYEe, YyEE, YyEe, YYEe, YYee, YyEe, Yyee,
YyEE, YyEe, yyEE, yyEe, YyEe, Yyee, yyEe, yyee.

or, combining these :—

1YYEE, 2YYEe, 1YYee, 2YyEE, 4YyEe, 2Yyee,
1yyEE, 2yyEe, 1yyee;

or, since Y and E are dominant,
9 yellow eyed plants, of which 1 is pure;
3 yellow eyeless plants, resembling one parent, of which 1 is pure;
3 white eyed plants, resembling the other parent, of which 1 is pure;
1 white eyeless plant, pure.

We have not only recovered our original parents in the pure condition, but we have manufactured, also in a pure condition, two new forms, the yellow eyed and the white eyeless.

By a knowledge of the behaviour of factors on which the character of the plant is based, it is, thus, possible, if we possess any particular set of combinations, and provided these include the two alternative forms, which we have here expressed as the presence (P) and (p) absence of each factor concerned, to build up and obtain in a condition of purity those combinations which we do not possess. An eyeless white-flowered cotton, for instance, does not occur in the Indian cultivators' fields; it has, however, been produced in the manner given above, and has been growing in a condition of purity for a number of years.

It is desirable that we should develop the habit of regarding the plant as built up of a number of factors, each of which

behaves as a separate and individual unit, and each of which is transmitted as a unit from parent to offspring. If we develop this habit the problem of improvement becomes one of identifying the unit factors on which the economic characters of the plant are based and of uniting these factors into one individual. We are now in a position to appreciate the difficulties which lie in the way of applying the principles of plant-breeding to cases of practical economic importance. These do not lie in the principles themselves or in the practical application of those principles. The main difficulty lies in the recognition of what constitutes a unit factor. In the above cases it is easy to determine whether the petal is yellow or white, whether it possesses a spot on the petal or no, for the distinction is marked and definite. The differences between characters which are of economic importance usually lack any such definiteness ; they are frequently merely questions of degree. Let us take, as an instance, the character of the ginning per cent. of cotton. It is of considerable importance that the ginning per cent. of cotton should be high, but the difference between a high and a low ginning per cent. is one of degree, and does not depend on the presence or absence of any obvious character. Ginning percentage is not, in fact, a physical character of the plant. It is the relation between the weight of seed and the weight of lint borne by that seed, and these, in their turn, depend on such matters as the size of the seed, the weight of the individual fibres and the number of fibres that arise from a single seed, all characters hard to determine and very indefinite. While, therefore, the scope of the plant breeder in the direction of the improvement of crops is great, we must recognise that it is work that is not simple, but one which requires training and application if success is to be achieved.

In the methods we have hitherto considered for the improvement of crops, we have assumed in the plant a capacity for developing flowers and fertile seeds. This capacity is not universally possessed by all plants. Further, many agricultural and economic plants, notably the sugar cane, the potato and the kela, though in some cases seed is obtainable, are normally propagated vegetatively. The potato crop, for

instance, is raised from tubers held over from the previous year, and a field of potatoes may thus very well be in reality all portions of the same individual. The same possibility holds both in the case of the sugar cane and in that of the kela.

If such plants are capable of developing seeds, as is the case with the sugar cane, which, though it rarely flowers and never sets fertile seed in the United Provinces, yet does both with fair regularity in the warmer climate of Madras and the islands of the Malay Peninsular, it is possible to proceed on the lines indicated above. We have, however, another possibility in this direction. At irregular intervals, with varying frequency in different plants and even different races, a vegetative variation, or what is known as a sport, occurs. A single cane, for instance, in one stool will develop characters in which it differs from the remaining shoots of the same stool. If that variation possesses economic value, we may isolate it, propagate it, and in this way build up a crop characterised throughout by that peculiarity. Such sporting is, as far as we can detect, due to no recognisable stimulus, and is what is termed fortuitous; we cannot direct it, and it is merely a question of maintaining a sharp lookout to seize and develop such as and when they arise. Such sports are not uncommon in plants normally propagated by seed; we not infrequently find a variegated branch, due to local absence of chlorophyll, on an otherwise normal plant. When we remember that whole areas of such plants as sugar cane are, in reality, merely portions of the same individual, the greater frequency with which sports are noticed in such cases is not a matter for surprise.

We may refer briefly to a further method of crop improvement. Many crops such as wheat, cotton, tobacco, maize and others are grown in many lands, and of these the produce of certain countries receives a name for quality, and, consequently, a higher price in the world's markets. Thus Egypt is noted for the quality of its cotton, Canada for the strong wheat which is produced, and many similar cases can be quoted. The question naturally arises: is it not possible to import seed of these and, by growing the improved quality, reap the benefit of the higher price obtained? Such importation is possible,

and the method has been frequently resorted to in the past. Even crops previously unknown have been introduced, and been established as one of the crops of the country. This is true both of the potato and of the maize. We cannot, however, accept wholesale importation without caution even when we exclude the importation of such obviously unsuitable plants as when a crop is introduced from a temperate into a tropical climate. Such acceptance would neglect the intimate relation which exists between the plant and its environment. It is not possible to foretell the effect a changed environment will have in any particular instance ; resort must be had to experiment. All plants possess, to a greater or less extent, an inherent power of adapting themselves to their environment, and that adaptation may be slow. It is not possible, therefore, to condemn an imported race on the grounds of an immediate lack of success. It is desirable that the trials should be repeated for a number of generations and over a considerable period. For more than a century attempts have been made to establish American cotton in India, and the earlier of these only attained partial success in the Dharwar tract. Recently efforts have been renewed both by the reimportation and by reviving the scattered remains of the older importations. The success that has been attained in these more recent attempts is confined to the latter class, and the long process of acclimatisation appears to have resulted in an adaptation which makes successful cultivation possible.

Chapter XXV

FACTORS OF CULTIVATION; THE FALLOW

In the few preceding chapters we have seen the manner in which the cultivator answers the first question he must ask himself, namely, what shall I grow, and we have explained in broad outline how he may be helped in that choice. Plant improvement, from this aspect, consists in placing a large number of races at the disposal of the cultivator, and from these he is able to select that one which repays him best. He now asks himself the second question; how am I to grow this? To answer this question satisfactorily he must possess that familiarity with the plant in question which will enable him to determine the conditions under which this plant will develop to the full. It is a familiarity which demands a personal knowledge of the plant. His business will, then, be so to alter the controllable factors of the environment that those conditions are attained. The practical means by which he exercises this control are included under the general term, cultivation. Looked at in this way it becomes clear that cultivation cannot be learned in the same manner in which an art is learned. It has no fixed and universal basis. Carpentry, for instance, is the art of manufacturing useful articles from wood; the material basis of the art, namely wood, is the same the world over. The material basis of the art of agriculture, the physical environment, is not thus uniform; both climate and soil vary from locality to locality, and, in consequence of this variation, expose an infinite number of variations on which the cultivator must exercise his skill. Even in one locality the climatic

conditions will vary from year to year, and the cultivator will be compelled to modify his practice in order to obtain the optimum result.

In many parts of England the farmer's primary consideration is to reduce the water content of the soil to permit him to sow his seed and to prevent the seed, when sown, from rotting owing to the excess moisture. Again, he pays considerable attention to the use of manures, artificial and otherwise, in order that the plant may not lack plant food. In the United Provinces and in the majority of the agricultural tracts of India, the occasions on which there is any excess of moisture are rare. In general the cultivator's object is to retain, as far as possible, every drop of moisture that reaches the soil. Here, too, the question of plant food is of less importance. Under the high temperatures of the hot weather and rains, weathering and the action of bacteria proceed at a more rapid pace than under the more temperate climate of England. Soluble plant food is more readily formed and not removed to the same extent as in a wetter and cooler climate. We must expect, therefore, to find a considerable difference in agricultural practice as carried out in the two countries. The practice of the one must inevitably lead to failure when blindly adopted and applied to the other set of conditions.

Agricultural practice, then, consists not of taking a standard article and fashioning it into different shapes—that is what the carpenter does when he takes a piece of wood and therefrom makes some article of furniture, it may be a chair or a table. Rather does it consist of reducing diverse conditions to uniformity; to that condition, that is, under which the plant will develop best. Nor is this all. The plant is a living organism, and, like all living organisms, requires a steady and constant supply of food material presented to it at all stages of its life. As the plant grows, its roots penetrate deeper and deeper into the soil, and, with that development, the depth at which the absorbing organs of the plant, the root hairs, are situated will become greater. It is to the area occupied by the root hairs that the supply of moisture, and with that moisture the soluble plant food, must be directed.

Cultivation, consequently, must vary with the development of the plant. Most agricultural plants, too, require a supply of oxygen to enable the functional activity of the living matter of the cells of the root to proceed in the normal manner which characterises a healthy condition. If we exclude for a moment such plants as rice, which are able to make use of the oxygen dissolved in the water of the soil, that supply is derived from the gasses contained in the interstitial spaces of the soil. Not only, therefore, must cultivation aim at maintaining as constant a supply of moisture as possible to the area occupied by the root hairs, but it must regulate the amount of that supply lest an excess lead to too great a reduction of the interstitial gasses and so lead to asphyxiation through lack of a sufficient supply of oxygen.

In tracts like those of the United Provinces the danger of such excess as is here indicated is small, and is limited to the relatively few occasions when a strong inset of the monsoon gives continuous heavy rain lasting over a period of several days, or when certain low-lying fields act as a drainage area to the surrounding country. The soil, generally speaking, is porous, and asphyxiation only occurs in the case of plants such as indigo, which are peculiarly susceptible to such conditions. In black cotton soil tracts this is not the case. With the advent of the rains such soil expands, expelling the interstitial air and leaving an impervious condition which, in the absence of any great depth of soil and of any marked subsoil drainage lines, renders percolation slow. Under these conditions a prolonged burst of the monsoon, even though unaccompanied by heavy rains, leads to asphyxiation and permanent injury to the plant. The success which has here followed the use of drains lies in the fact that these provide the necessary drainage lines. Into them the excess water passes, and air passes into the interstitial spaces.

The exact procedure that must be followed, thus, depends on the local conditions, on soil and climate, and even in one locality must vary from year to year with the variation in the latter.

We have already referred to the weathering effect that exposure to air and sun has on the soil, especially under the

high temperatures common in India. Such effect will be progressive with the length of exposure, and what is more important, still with the surface area exposed. Now the area exposed is the sum of the surfaces of the exposed soil particles, and, clearly, this will be very much greater if we break up the surface left smooth and hard after removal of the preceding crop. To do this we must plough the land as soon as possible after the crop has been removed, even irrigating if the soil is too hard for the plough to enter without so doing. The soil is then left uneven and open throughout the hot weather, as in this condition the maximum amount of surface will be exposed. Nor is the advantage of opening up the soil limited to this. The first rain of the monsoon now falls on to a broken surface; surface flow is checked, penetration is rapid, and every available drop of rain passes into the soil carrying with it the soluble material developed by exposure to weathering agents. Let us compare this with what happens when the land is not ploughed till after the first rain has fallen. That rain falls on a smooth beaten surface, having few openings to admit of ready percolation. Percolation is, therefore, slow, and if more than a slight shower falls surface flow will be large. This constitutes not only a loss of valuable water, but such soluble salts as have been formed will not be carried down into the soil, but will, in large measure, pass off with that surface flow. The exact extent of that loss will depend very largely on the nature of the first rain. If this is light, merely wetting the surface sufficiently to make ploughing possible, that loss will be negligible, and failure to plough before the hot weather commences merely means a certain reduction in the products of weathering; but if this be heavy and continued, ploughing will be impossible until a break occurs, and the loss through surface flow may amount to a considerable figure.

During the first half of the rains our main effort will be directed to catching as large a portion of the rainfall as possible, to affording it means for readily penetrating into the soil and to conserving it when there. As left by the plough, the soil lies in aggregates composed each of a larger or smaller number of particles. The pores through which water penetrates into

the soil are, therefore, relatively large, and penetration is rapid. The effect of the rain on these aggregates is, by impact, to break them down into their ultimate particles, and the smaller of these are carried by the water as it passes into the soil until their passage is no longer possible owing to the size of the pores. The soil thus becomes progressively less and less permeable. When this takes place and the rate of percolation is perceptibly reduced, it becomes necessary to open out the soil by renewed ploughing, and this must be done as soon as the condition of the soil allows it to be worked. That means a break in the rains, and that break may be of short duration or prolonged. At first we may anticipate an early renewal of the rain and leave the land open accordingly ; but, should the advent of rain be delayed, we will run the risk of excessive loss by evaporation of the water we have been at pains to conserve. Under these circumstances we must break down the loose aggregates cast up by the plough to form a loose surface mulch, checking evaporation, while not forming too great an obstacle to the penetration of further rain when this eventually falls.

As the season progresses, other considerations begin to take precedence. We intend to sow wheat, and, for successful germination, we require an ample supply of moisture near the surface of the soil. The matter would be fairly simple if we knew definitely which would be the last rain. Could we, for instance, be assured, after receiving rain early in September, that we will receive more at the end of September or early in October, we would make an effective mulch by drying out the surface layer of the soil and rely on our late rain to re-establish a sufficient water content to the upper layers. Our rainfall, however, is not sufficiently reliable for us to base calculations on such assumptions. After early September we must act as if each rain were to be the last ; that is, we must make our primary object the development of the optimum moisture conditions for germination and relegate to a secondary place the conservation of the rainfall already stored, as well as the provision of an easy passage for the penetration of such later rain as may be received. In other words, our mulch must be shallow and, to make it effective, fine.

We have so far considered the object of cultivation to be merely weathering and the conservation of moisture. These, however, are not the only considerations. In an earlier chapter we discussed very briefly the action of bacteria in the soil, and laid particular stress on those actions which were concerned in what we termed the nitrogen cycle. Since nitrates form one of the most essential plant foods, it becomes of the utmost importance to develop conditions which are favourable to the active development of the nitrifying bacteria, conditions which we have seen are aerobic. Equally is it essential to avoid anaerobic conditions, for such will lead to the destruction of any nitrates that may have been formed. Now anaerobic conditions are produced by waterlogging, and the procedure we have indicated, namely, keeping the soil open to allow of as rapid a percolation as possible, inasmuch as it reduces the time water will stand on the land, favours the bacterial action we require. But this, in itself, is insufficient. Prolonged periods of rain, or of intermittent rain so distributed that it is impossible to get the ploughs on to the land, will develop a condition, in any but very light soils, in which percolation ceases. Unless the levels of the fields have been carefully attended to so that even the shallowest of depressions does not occur, water will accumulate locally and develop anaerobic conditions. To anyone who has had no experience in such matters it is hardly credible how small such a depression need be, and for how short a period anaerobic conditions need prevail, to produce complete destruction of the nitrates and a consequent impoverishment of the succeeding crop—an effect, no doubt, attributable to the rapidity of the bacterial action at the temperatures then prevalent.

We may turn to a consideration of the implements required for the purpose of attaining our object, as described, to the full. The object of the initial ploughing is to expose as large a surface of soil to the weathering action of the air, and also to open up the soil to ensure rapid penetration of the early rainfall. Clearly, this will be best accomplished by opening up the soil to as great a depth as possible. For such a purpose an iron inverting plough is most suitable. For the same reason an

inverting plough is desirable during the early course of the rains, for our main object remains the same throughout this period. The use of such ploughs, however, requires caution. If we use a plough penetrating to eight inches on land that has hitherto only been cultivated with a country plough penetrating to four inches, we are at once diluting the weathered soil with its own volume of subsoil. The characteristic of subsoil is a lack of friability which works against the production of a good tilth. The first effect of using an inverting plough to its full depth of eight inches may thus be, and this is especially true of heavy soils, to destroy tilth and, with it, fertility. It may well happen, in these circumstances, that the immediate effect of the use of these ploughs will be a reduction of yield. Such a result is likely to prejudice their use, but such loss of yield will be temporary only, and each year will show an improvement, which will ultimately develop into a fertility much in excess of the previous normal. The danger can be obviated by applying discretion to the use of such ploughs in the commencement, gradually increasing the depth turned over each season until the maximum is attained.

Another danger attaches to the unguided use of the iron plough. A plough, such as the Watts, if used in the same manner as the desi plough, throws the earth outwards only, and the inevitable result is the production of a hollow in the centre of the field. Waterlogging now follows as a natural consequence. Especial care is necessary if such destruction of levels is not to result, and for the purpose a pattern of turnwrest plough is preferable, for this allows the soil to be thrown a different way with each ploughing.

In the latter stages of the monsoon, as we have explained, our primary object changes. We cannot afford to open up the soil to the same depth for, in the absence of later rain, we will be unable to restore a sufficient water content to the upper layers which go to form the seed bed. We must now use the country plough, with or without the patha, as circumstances dictate.

If we succeed in our object, it should be possible, even in years of low rainfall and of early cessation of the monsoon, to

develop a seed bed having sufficient moisture to ensure full germination and a healthy stand without palewat.

We may give two examples to illustrate the manner in which seasonal differences in rainfall affects the actual cultural operations.

PREVIOUS CROP (JOWAR AND ARHAR).

Mid-April.	Irrigated and ploughed with iron plough.	
4–12 June	Rain	1·42 in.
15 June	Ploughed (iron)	
15–30 June	Rain	4·27 in.
1–31 July	Rain	19·17 in.
2 Aug.	Rain	0·23 in.
5 Aug.	Ploughed (iron).	
6–31 Aug.	Rain	2·34 in.
1–9 Sept.	Rain	4·00 in.
14 Sept.	Ploughed (iron)	
16–17 Sept.	Rain	1·34 in.
20 Sept.	Ploughed (desi and patha).	
26 Sept.	Rain	0·10 in.
29 Sept.	Ploughed (desi and patha).	
13 Oct.	Ploughed (desi and patha).	
24 Oct.	Sown.	

PREVIOUS CROP (COTTON).

17 April	Irrigated.	
20 April	Ploughed with iron plough.	
5–16 June	Rain	0·07 in.
11–16 July	Rain	3·57 in.
17 July	Ploughed (iron).	
1–15 Aug.	Rain	1·56 in.
16–31 Aug.	Rain	2·89 in.
1–2 Sept.	Rain	0·07 in.
3 Sept.	Ploughed (iron).	
3–30 Sept.	Rain	12·93 in.
5 Oct.	Ploughed (iron).	
5–12 Oct.	Rain	1·36 in.
16 Oct.	Ploughed (iron).	
18 Oct.	Ploughed (iron).	
28 Oct.	Rain	0·01 in.
3 Nov.	Ploughed (desi and sown)	

In the former year it would have been desirable to add ploughing during July had it been possible to do so; in other respects the most is made of the free early rainfall. During the latter half of the rains in this year it becomes necessary to develop a mulch to check evaporation. In the latter year the rainfall is accumulated in the latter half of the season, and the date of the latest fall is such that it is necessary to open out the land to prevent the development of an excess of moisture in the seed bed.

Chapter XXVI

FACTORS OF CULTIVATION; INTERCULTURE AND MANURING

Such cultivation as we have till now considered is merely preparatory, for the crop has yet to be sown. During the later stages of this preparatory cultivation our main object was to develop in the surface soil those conditions which form the optimum for the germination of the seed. We have now to consider the procedure necessary to bring the seedling which develops from that seed to maturity so that the yield may be the maximum.

We must remember, too, in this connection, that growth of most agricultural plants is continuous, and necessitates a constant supply of plant food, and, consequently, of soil moisture. For, just as we ourselves will remain healthy only when we receive regular meals, and will soon become ill if we attempt to live on one meal a week, however abundant that meal may be; so will the plant be weakened by alternating periods of high and low food supply when the intervening period of low supply is too prolonged. It is true most plants show a recuperative capacity of no mean order, and can withstand considerable periods of drought without material weakening of constitution; but there comes a stage when the check is material and permanent and recovery becomes impossible. Such a check, if administered in the early stages of growth, may mean a permanent weakening of the plant which will appear later as a diminished yield. We may draw a comparison between the missing of an odd meal and the exposure of a young child to a period of insufficient food. The former

does no permanent harm, while the latter develops a physical weakness, which remains through life.

We have, therefore, to regulate the supply of moisture to the roots in such a way as to reduce as far as possible the magnitude of the fluctuations that must occur. Again, we start from a basis which has been determined for us by natural causes, and are compelled to work towards, instead of from, a constant. In general, the cold weather is a season of low rainfall, and we cannot depend on the receipt of any rain, though a valuable fall may be anticipated early in the year. We are consequently faced with a diminishing moisture content of the soil, which is naturally greatest near the surface. We have, too, if we have succeeded in our object, accumulated a considerable bulk of the monsoon rainfall. Clearly, under these conditions, our object must be to develop as deep a root system as possible. With a deep root, penetrating well into the subsoil, the root hairs will be situated in a region of maximum moisture and minimum fluctuation. Now the root of a plant is markedly hygroscopic, and the cultivation that we have indicated, which accumulates moisture in the subsoil, and only raises it to the surface for the purpose of germination, is, therefore, admirably adapted to develop a deep root. The root is, so to speak, drawn down in pursuit of the moister layers as the soil becomes progressively drier. The root, too, will be aided in achieving this in a soil which has been disturbed by an iron plough, for penetration will be facilitated through the more open texture.

During germination and the period of seedling growth no cultivation is required ; the conditions are such as to develop the plant in the direction required. We must not forget, however, that we are all this time losing valuable moisture for, to prepare the seed bed, we were compelled to compact the soil in a manner that leaves a very imperfect mulch. It will, for this reason, be desirable, as soon as the plant is sufficiently established, to perfect that mulch by harrowing the surface. Such harrowing will not only check evaporation, but will open out the soil and render percolation, when irrigation is resorted to, more rapid.

The time of the first irrigation will vary with the nature of the previous monsoon and with the physical condition of the land. When the monsoon rainfall has been light, water must be given comparatively early, in December. The plant will at that time be sufficiently small to allow of the use of a harrow to form a mulch and to prevent a too rapid loss of moisture. When that rainfall has been heavy, it may not be necessary to irrigate till the crop is earing out in January, and in this case, with seasonable cold weather rains, an irrigation may even be unnecessary.

We have now to look forward, in the same manner as we found to be necessary during the latter part of the rains, and study the requirements of the ripening crop in order that we may make preparations for the development of the optimum conditions at that stage also. A full yield of wheat will only be obtained when each individual grain is well formed and fully filled. The ripening process consists in the transference of the food material stored in the vegetative portions of the plant to the grain. For such transference to take place the food material must not only be in a soluble form, but there must be a sufficiency of moisture in the tissues to make that transfer possible. A full plump grain will only be obtained, therefore, if the plant ripens off slowly. A sudden ripening, such as is brought about by an early spell of hot winds, means that the tissues dry up before translocation of food material is complete, means, that is, a shrivelled grain and a low outturn, but a bhusa comparatively rich in carbohydrates. We cannot control the nature of the winds, but we can, to a certain extent, check early ripening by ensuring a water supply to the roots sufficiently plentiful to meet the additional strain imposed on the transportation current by the dry atmosphere. Such control must be our primary object during the later stages of growth. Our latest irrigation, thus, must not be too early, or it will not be effective in ripening off a plump grain.

This conclusion may be expressed by saying, delay the last irrigation to the latest date possible. But what is the latest date, and why should we not ensure a sufficiency of moisture at this time by irrigating, let us say, a week or so before

harvest ? Let us look at the growth of the wheat plant in its later stages a little more closely. At the time of earing out the glumes contain a small and diminutive ovary into which the food material gradually passes. The size of this ovary increases, and, with it, the weight until the stem is supporting a considerable load at its upper extremity. The immediate effect of irrigation is to loosen the hold the roots have on the soil, and the removal of that hold, combined with the increased load, results in the laying down, or lodging, of the crop if there is any wind at the time of irrigation. We must complete our irrigation, therefore, before the danger of lodging becomes a factor which must be taken into account. We have, thus, as determining factors of the date of our last irrigation, an early limit set by the danger of lodging and a late limit set by the need for maintaining a sufficiency of moisture in the soil up to the time of ripening. The period between these two limits is a short one, sometimes so short that it may not be possible to apply the last irrigation between them. This is especially the case in those tracts commanded by canals giving an intermittent supply. It will then be necessary for us to choose between early irrigation, with the risk of early hot winds shrivelling our grain, and a late irrigation, with the risk of lodging. The time of application of the last irrigation is, thus, even when the water supply is assured, a matter requiring considerable judgment.

We have attempted to describe the cultivation of a wheat crop in such a manner as to bring out the more important or, as we may call them, the critical stages, of the process with the reasons for each successive stage. It is one example merely, and each crop must be considered in its relation to the environment in a similar manner. If we have followed the description we will understand that each process has a definite object. We do not plough a field merely for the exercise involved in following the plough, nor to find employment for our cattle. We have a definite object in each stage, and that object is to assist the plant growing, or to grow, in that field to attain to a perfect development. It is true that we cannot always explain how a particular procedure leads to a beneficial

result; in some cases the experience of generations of cultivators has developed a practice which is ill-understood. Such cases form matters for investigation; we are not yet all wise. On the other hand, knowledge of causes and their effects have enabled, and will continue to enable, us to improve on practice as dictated by experience. We will widen our experience and gain a better insight into such matters if we ask ourselves, each time we see a cultivator actively engaged on his land, why he is spending his labour in that particular manner.

We have seen that, among the other benefits derived from cultivation, is the development of plant food, whether it be as the result of weathering on the mineral matter of the soil directly or of bacterial action. The former is most active during the hot weather, while the latter will develop most intensely during the rains, though the controlling influences are not fully known. The most important form of bacterial action, from the general agricultural aspect, is that which concerns the nitrogen cycle, the main features of which have been given in a previous chapter. Under full control, or, in other words, on occasions when we are in a position to develop throughout to the maximum the activity of the nitrifying bacteria, the result will equal in value the effect of a full nitrogenous dressing. The wheat crop following such a fallow as we have described above will possess the full rich colour characteristic of the plant receiving a plentiful supply of nitrogen. Under favourable conditions wheat crops of 30 maunds and over can be grown on land which receives no other nitrogenous manures; crops, that is, which rival those produced under the systems of intensive cultivation practiced in England and Continental Europe.

The essential element, in this case, is nitrogen, and the amount of nitrogenous plant food is only limited by the rate of bacterial action, for the source of that nitrogen is unlimited, being the free nitrogen of the air. Of other elements of plant food, of which the chief are phosphorus and potassium, there is not the same unlimited supply. The limit is here set not merely by the rate at which weathering takes place, but also by the amount of insoluble salts exposed to the weathering

agents, clearly a decreasing amount. It is possible, therefore, that a time may come when such essential elements may not be developed in an available form in sufficient quantity to meet the requirements of a full crop ; a condition which is especially liable to arise in the plains in the case of phosphorus. A deficiency in the supply of nitrogen is also to be anticipated under a do-fasli system, which prevents the same freedom in the control of bacterial action as is possible in the case of an ek-fasli system with its long fallow. Certain crops, too, particularly sugar cane, maize and potatoes, are exhausting crops, that is, require a relatively large amount of plant food for their growth. Under any such conditions we must, if we are to develop a full crop, increase the supply of the deficient element by artificial means. Such means involve, usually, the direct addition of a substance containing one or more of the essential elements. The process of addition is known as manuring, and the substance added as a manure. We can recognise several classes of manures.

The first include the mineral manures, of which the simplest are those which are directly available as plant food. Of such a nature is saltpetre, or sodium nitrate. Sodium nitrate is a soluble salt and passes at once into solution in the soil moisture. It is, thus, immediately available, and can be applied at any time as long as it is brought into contact with the soil moisture. It may be applied during the growth of a crop, and, if so applied, before irrigation, the effect is immediately observable in the deeper green of the foliage. Superphosphate and bone meal are, again, mineral manures, less readily soluble and requiring to be weathered before the phosphorus becomes available. These must be applied before the crop is sown or benefit will not be derived from their use. Ammonium sulphate, again, is a soluble salt, but the ammonia requires to be converted into nitrate, a bacterial action, before the nitrogen becomes available.

Organic manures, farm-yard manure, cakes and such like form a third class, of which the action is more complex. They contain many complex chemical substances, and are usually rich in nitrogen, to the presence of which their value as manure

is largely due. That nitrogen is, however, in a combined form, and such nitrogenous bodies require, as we have seen, to be decomposed by bacterial action before the nitrogen appears in an available form. They contain, in addition, a large amount of material of the nature of carbohydrate. This acts as a medium for bacterial growth, and it is the decomposition of this material which forms humus. Not the least of the benefits of manures of this class is the formation of this humus, the presence of which in the soil influences in no inconsiderable measure the physical condition and the moisture content. Such manures must be applied a sufficient time before the crop is sown to allow the necessary decomposition to take place.

Lastly, we have the system known as green manuring. A crop is grown merely to be ploughed in and form a manure for the succeeding crop. Commonly the crop ploughed in is a leguminous one, and these are chosen owing to their comparative richness in nitrogen. Let us look at the process in some detail. The living plant consists of a scaffolding formed by the cell walls, which are mainly composed of carbohydrate. Within this scaffolding, within the cell, that is, lie the more complex organic substances, the decomposition of which forms the food material of the succeeding crop. It is these latter substances which contribute most of the nitrogen that has manurial value. But such nitrogen is not immediately available, and requires prior decomposition by bacterial action. Before, however, bacteria can obtain access to the cell contents the cell wall must be broken down. This, again, is a bacterial process, and one which is, as we have seen, most active under anaerobic conditions. By ploughing in the green crop we are relying on bacterial action to produce for us those substances which are of direct manurial value, and for this purpose we see that we may expect the most immediate and satisfactory results if we can control the conditions so that we have a period of anaerobic conditions followed by a period during which the conditions are aerobic. Such a control in the field is difficult, if not impossible, for we have no control over the rainfall. If we plough in our crop, relying on subsequent rains to develop anaerobic conditions sufficient to produce rapid

decomposition of the cell wall, a failure of rain will involve incomplete decomposition, and the formation of intermediate substances which may even be actively harmful ; while, if prolonged rains follow such ploughing in, we may get not only decomposition of the cellulose, but also denitrification. The danger of the occurrence of this latter is particularly great in hot climates where bacterial action is so rapid, and more certain results can be obtained by pitting the cut crop instead of ploughing it in. Pitting is simply a means of controlling the conditions of bacterial action. In the pit anaerobic conditions are readily produced, and the decomposition of cellulose can be made to proceed apace. When this has proceeded sufficiently far, the partially decomposed matter is spread on the land and ploughed in. It now becomes exposed to aerobic conditions leading to the formation of nitrates. The economic value of this method of pitting in place of directly ploughing in the green crop is a matter we need not discuss here. The importance of the operation lies in the fact that it gives us an illustration of the directed method of agricultural development. It is our knowledge of the various factors at work that indicates to us a method that would not readily be evolved by any empirical method, the method we have termed one of trial and error.

CHAPTER XXVII

FACTORS OF CULTIVATION; PHYSICAL CONDITION AND SPACING

WE have defined the object of cultivation as being the development of those conditions which are most favourable for the full growth of the plant. We must presuppose, therefore, a knowledge of the requirements of each plant. Such a knowledge is largely a matter of experience for all the commoner crops, and it is only when we come to consider the more intimate differences between crop and crop, as when we are concerned with the relative requirements of two races of wheat, that the matter becomes one for experiment. We know by experience what lands will carry a crop of wheat, for instance, and what lands will only carry a crop of barley. We would not plant sugar cane on land suited to bajra nor sow cotton on rice land. The reason we do not do these things is that experience has taught us that the land in question differs from that which constitutes the optimum for the crop by an amount which cannot be corrected by any means at our disposal. We are thus led to a classification of land in accordance with the crops they will carry, and, by a natural transference of thought, come to grade the land, considering the best to be those which will produce the most valuable crops. We further connect with that grading the idea of fertility, placing as most fertile those which will carry crops such as sugar cane, tobacco, potatoes, maize, wheat, and so on.

Fertility is, thus, a measure of the value of the crop that can be raised. It is not necessarily a measure of the amount of plant food available in the soil, or, indeed, of any other single factor affecting productivity. Plant food is a question we have considered very briefly, but the presence of a sufficiency of plant food is, of itself, not enough, for there may not be a sufficiency of moisture to render that plant food available. Even the presence of a sufficiency of both plant food and water will not be enough to produce a crop if the texture of the

soil be such that the movement of soil moisture is too slow to keep the plant regularly supplied. We are, therefore, led to the consideration of another set of conditions affecting crop production which are mainly dependent on the physical condition of the soil, and we are led, further, to enquire how far we are able to alter these physical conditions in the direction of improvement. In the cases dealt with hitherto we have accepted the class of land as the starting point, and merely considered how, by cultivation, we can develop in it the conditions most favourable for that crop which we know we will be able to grow. The problem is a temporary one, and the effects of our efforts are restricted to the immediate or, possibly, the succeeding, crop. The problem now before us is a more permanent one; it is to consider how far we are able to alter the nature of the land in the direction of increasing fertility: in the direction of raising it from a lower to a higher class. We are dealing here with the physical aspect of the soil.

We may exclude from our consideration the bearing of locality on fertility. Certain lands owe their lack of fertility mainly to such location. Large tracts of the Punjab, for instance, remain uncultivated only on account of the lack of water. As the development of the Canal Colonies prove, they are, in all other respects very fertile. Rice lands, again, are unsuited for the growth of more valuable crops, mainly because they are low-lying and subject to inundation. Excluding cases of this nature, we find that the most fertile soils are those to which we apply the name of loam. The soil of these is readily worked and friable, movement of soil moisture is neither too rapid nor too slow, and root penetration is not a matter of difficulty. This condition is due, in part to the size of the soil particles and in part to the capacity possessed by these particles of adhering together to form aggregates. Divergence from this optimum physical condition occurs in two directions. On the one hand are the so-called light lands, passing through all stages to sand, and, on the other, the heavy lands, with a large percentage of clay, represented in the extreme form by certain of the Usar lands of the United Provinces.

The main physical defect of the sands is an inability to retain moisture. Rain falling on them passes rapidly away, carrying with its flow a considerable portion of the soluble salts. The water content of such soils will undergo rapid fluctuation, and the plant is, therefore, exposed to an alternation of conditions which may affect its growth materially. Improvement here must be in the direction of increasing the retentive capacity of the soil, as, for instance, by the application of lime or humus in order to check the loss of plant food through maintaining a relatively constant water content.

In the clays, on the other hand, our efforts must be directed towards increasing permeability. The tendency to form aggregates must be encouraged and the amount of colloidal material diminished. The addition of gypsum, the partial burning of the surface soil or the application of a dressing of a suitable porous material are steps which may be taken in this direction. The action of these will be to open up the soil to percolation and root penetration and, in addition, the soil so opened up will permit a more rapid weathering and bacterial action. It is a common experience that such lands develop under some such treatment a high degree of productivity for such crops as possess a root system sufficiently strong to penetrate deeply.

It will help us to understand the nature of these heavy soils, as of another class, the reh soils which cover so extensive an area in the western United Provinces, if we follow briefly their mode of origin. The soils of the plains of Northern India are entirely alluvial, and must, at some distant period, have passed through a stage comparable with that now seen in the Gangetic Delta or Sunderbands. The successive stages through which the country round Cawnpore, for instance, has passed are represented by the Sunderbands, Lower Bengal, and, finally, Bihar and the Eastern United Provinces. Even in the latter tract we find many instances of low-lying lands which form blind backwaters inundated by flood-water from the rivers. The water which reaches these lands is not a direct flow from the main current of the river, and, consequently, only the finest particles are carried into these back-waters.

The bed that is gradually built up is composed, therefore, of only the finest silt, and if, subsequently, any diversion of the river brings the main current to this area we will obtain a superimposed deposit of coarser material. It is by such changes and shiftings of the river that the alluvium has been built up and a transverse section, could we obtain one, would appear as a series of lenticular masses of such fine clays, varying in thickness, lying in a mass of coarser deposit. In the course of time these sedimentary deposits become consolidated by pressure, and if now one of these lenticular masses becomes subsequently exposed it will form an irregular area which is barren owing to the physical nature of its texture mainly due to the fineness of the individual particles. Of such a nature are a large number of the Usar patches so common in the central United Provinces. At an earlier stage of their development they were jheels receiving water from the overflow of the rivers when in flood.

Such a deposit will frequently be cup-shaped and probably thicker in the centre than at the margins. Let us now suppose that this deposit is overlaid by a further deposit of coarser and more permeable material. The monsoon rainfall, falling on this area will carry the salts formed by weathering action into the cup where they will be retained until, during the following dry season, they are again drawn to the surface. Under these conditions there is no loss of salts; on the other hand there may be a gradual increase, the result of weathering, and it is possible under favourable conditions for an accumulation of such salts to arise, which will appear as a white deposit on the surface in certain seasons. This white deposit is known as reh. The exact nature of the salts will depend on the material from which they arise. In many cases they are composed of carbonates, chlorides, or sulphates. Such reh soils are barren, or usar, because they produce a concentration in the soil moisture which is sufficiently high to cause plasmolysis in the cells of those roots which come into contact with it. The plant, therefore, dies of drought. This land is usar, which simply means barren, but for a reason very different from that which we have seen to be effective in the former case; and any

method of removing the excess of salts will leave a potentially fertile soil, for these lands are light and permeable. We say, potentially fertile, for the method adopted for removing the excess of salts will also remove the soluble plant food, and addition of plant food may prove to be necessary before full fertility will be developed.

The essential conditions for the development of such reh lands is an impervious, and probably cup-shaped, underlying

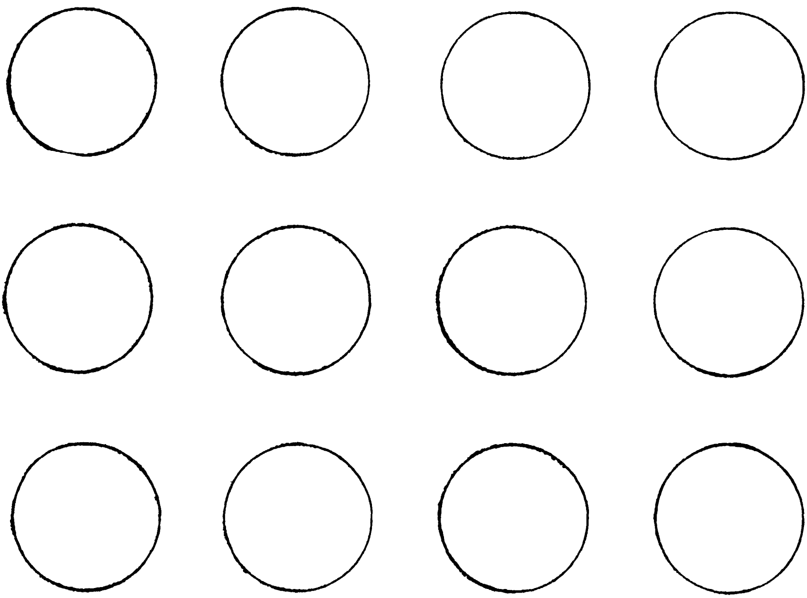


Fig I

stratum. We have suggested that such a layer may be comparable to one which, if exposed, will give an usar area of an entirely different nature. But this is not the only way in which an impervious layer may arise. The presence of kankar is common throughout the plains, and it usually occurs in beds. In some cases the kankar is so plentiful that it forms a continuous deposit, commonly termed a hard pan, which is impervious, and such a kankar bed will give rise to conditions favourable for the development of this particular form of usar.

Nor need we assume the presence of an impervious under-

lying stratum to be essential. Any conditions which promote active weathering on the surface with a supply of moisture insufficient to carry away the salts so formed will develop reh if the nature of the weathered material is such as to give a large amount of salts not removed by the plant. These conditions arise in tracts of low rainfall which is insufficient to penetrate to the general level of the subsoil water.

We have so far discussed the subject of improvement, defined as the extraction of a greater money return from the unit area, both from the aspect of the single plant and of the

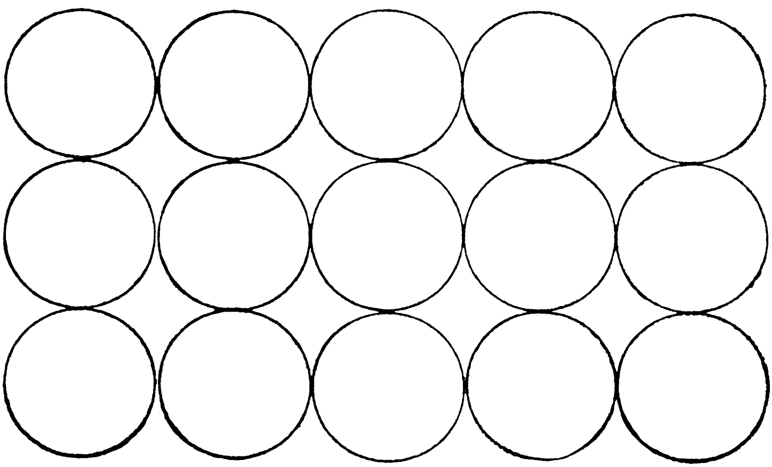


Fig. 2

medium in which it grows. There is yet another aspect, as we shall see, if we consider the question of outturn only. The outturn from a particular area is the sum of the individual yields of all the plants growing on that area. What we require to do, therefore, is to determine, not the conditions under which y is greatest, but the conditions under which ny is greatest; y being the plant yield and n the number of plants in the given area. Hitherto we have only discussed the former, and have neglected to take into account the number factor.

If we consider the growth of a single plant isolated in a field which is otherwise vacant, we will see that its roots penetrate in all directions, and its source of supply may, therefore, be

represented by a circle of which the stem forms the centre. The simplest case of a crop will be that in which the distance between plant and plant is such that the areas drawn on by neighbouring individuals do not come into contact (Fig. 1). Each plant is here able to develop to its maximum extent. Fig. 2 shows that symmetrical arrangement of plants which will combine maximum yield of the individual with maximum number of individuals; for, if any closer arrangement is resorted to, we will have root interference arising. Such a system is not, however, making the maximum use of the land,

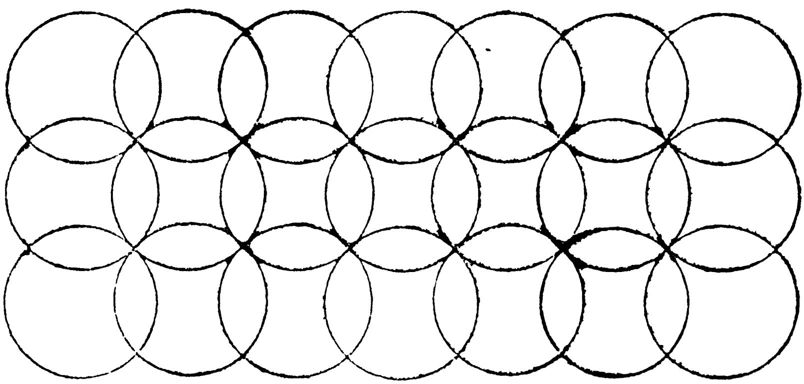


Fig. 3

for there are, under it, definite areas to which roots do not penetrate. To achieve this purpose the united root systems must penetrate to every portion of the land, and we must plant closer still (Fig. 3). Under these conditions there arises competition between neighbouring plants for the available food material and water supply. Consequently the yield of the individual plant will be diminished, but such diminution will be more than made good by the increase in the number of plants. A good system of spacing would ensure, not only complete penetration of the area by the roots, but that each individual plant will receive access to a uniform supply.

There are certain reasons, however, which render this ideal spacing unsuitable in practice. Not the least of these is the labour required to place each seed at the measured distance

from its neighbour. In planting out fruit trees such a system is possible, for the cost of labour is incurred once only in the course of a number of years, and the number planted in a given area is relatively small. It is a different matter, and becomes impracticable in the case of a crop like wheat, where the inter-plant distance is approximately a foot only, and the process has to be repeated annually. Fortunately we are in a position to compromise by sowing plants at short intervals in lines, leaving a greater interval between successive lines, for the plant exhibits a certain amount of flexibility in the matter of root penetration. Let us consider the case of a crop sown in lines 18 inches apart, with 6 inches interval between the plants in one line. Any particular plant in such a system will early come into competition with its neighbours on the two sides of the line for the available supply of moisture, and a region of relative dryness will result along the length of the line. Laterally, on the remaining two sides that is, this competition will not develop so early, and the region between the two lines will thus become a region of relative humidity. Now we know that roots are hygroscopic, and such planting, therefore, stimulates root penetration in a lateral direction. The area of supply in this system will no longer be represented by a circle, but by an oval, and, with judicious selection of the interval between successive lines, we shall lose nothing in yield by such a system of planting. We must also remember that the same arguments which we have applied to the root apply also to the shoot, for competition arises between the shoots of neighbouring plants for light and air.

The advantage of spacing a crop thus arises from considerations of a somewhat fundamental nature. We have to aim at the condition which will make the value ny a maximum. Spacing is not without certain subsidiary advantages, however. It facilitates interculture during the growth of the crop, in many cases rendering it possible to employ cattle and implements in place of hand labour with the khurpa.

CHAPTER XXVIII

THE EXPERIMENTAL METHOD

IF we review what has been said with regard to the various directions in which improvement on the present-day practice of agriculture is possible we will be enabled to classify the methods indicated under five main heads :—

(1) Improvement of the plant; by the development of pure races, whether by means of selection or hybridisation.

(2) Control of the water supply.

(3) Control of the food supply.

(4) Improvement of the physical conditions of the soil.

(5) Control of the distribution of the plants so that the area-yield may be the maximum.

In the past a certain and considerable amount of practical experience has been acquired on these heads by the cultivator, and the sum of that experience is gathered together to form the agricultural practice of the country. The degree of efficiency is high, but it has been developed by an undirected process of trial and error. We are now in a position to enquire whether there is no method of directed enquiry which will enable us to discover, through our knowledge of the cause of any observed failure to obtain the full measure of return, a remedy for that failure. As the result of our better understanding of the relation between cause and effect, we may be led to conclude that a certain procedure is likely to prove beneficial, and we have now to enquire how we may set about testing our conclusions by what we have termed a directed method. The essential points of such an enquiry will be brought out by the consideration of a few specific instances.

Let us suppose that we have isolated some half-dozen races from a crop of wheat. We have now to ascertain which of these will give the best outturn under the local conditions. The

problem does not sound difficult, for it appears easy to grow six areas of equal extent and to measure and compare the resulting yields. But of what value is such a comparison? Let us assume the six races come out in the following order; A giving the largest yield, followed successively by B, C, D, E and F. Let us now sow another six plots in the same neighbourhood, or even in a different part of the same field, and again compare the yields. It is more than probable that the races will not appear in this second series in the same order as that in which they appeared in the first. The order may now be D, B, A, C, F, E. We now begin to see the difficulty that attaches to making a definite determination of the best variety. There arises what is known as an experimental error in such determinations, and this error may be very large. In such cases we can only state with certainty that one race is a better yielder than another if we are in a position to determine the experimental error and to see that its value is small in comparison with the observed differences between the two yields. Such experimental errors owe their origin mainly to inequalities in the land which varies, even in the most uniform fields and within a few feet, sufficiently to vitiate any results based on a comparison between neighbouring fields or even on two sections of the same field.

If, now, we divide our field into a large number of plots and sow these to our six races so that each race appears scattered throughout the area, we will have a series of determinations

A	D	F	C	E	B	A	D	F
B	E	A	D	F	C	B	E	A
C	F	B	E	A	D	C	F	B
D	A	C	F	B	E	D	A	C
E	B	D	A	C	F	E	B	D
F	C	E	B	D	A	F	C	E

of the yield of each race, and we will be able to compare the figures for the average yield of each with far more confidence than any other set of figures obtainable from the same area. We are, moreover, from such a series of figures, able to obtain an accurate measure of the experimental error, and we will, when discussing results, take the precaution of considering only such differences as are of larger measure than our experimental error as determined. Thus, not only are we able, by such a method of experiment, to obtain more accurate figures for our yields, but we are enabled to measure the degree of their accuracy ; to know whether any observed difference is a real or accidental one.

The error of experiment will vary with the crop, but it is large in all cases, and it is important, therefore, that we should be able to recognise it and determine its magnitude. In India, and especially the United Provinces, it is larger for cotton than, perhaps, for any other crop, and it is by no means impossible for the error here to amount to 300 or 400 per cent. even on lands apparently uniform and uniformly treated. With such errors possible it becomes of vital importance to adopt the system of scatter plots, or, as it is sometimes called, the chess-board system, for comparative trials, because it supplies us with definite information as to the magnitude a difference must be before it can be accepted as significant. It is useless discussing a difference of 1 maund per acre if we know that the probable error of the experiment is 2 maunds.

Variety tests are not the only ones to which this system of scatter plots may be adapted. Tests aimed at discovering the best distances for spacing, the effects of different cultural methods and the food requirements of the plant all involve an experimental error which must be determined before we can with certainty interpret our results. We will here discuss one other example merely as an illustration of the directed method to which we have made frequent reference.

As we know, the plant requires as food certain substances which must be present in sufficient abundance if full development is to be attained. The elements essential as food are known to us, and from analysis of the soil and of the crop we

are able to determine not only the amount of those substances essential to the plant, but also the amount present in the soil. It would seem, therefore, a simple matter to determine by analysis in what elements the soil is deficient, and, from this knowledge, to deduce the nature and quantity of the substance that must be added as a manure. In practice, however, this is not so, even when the analysis is limited to the determination of what is known as the available, as opposed to the total, supply. It is by no means uncommon experience to find that a crop will respond to a dressing of a particular manure when analysis indicates that the essential element in that manure is already present in the soil in an amount many times that required by the plant in question. Chemical analysis may be a guide in the determination of what is deficient in the soil, but the only really effective means of ascertaining the real requirements of the plant is by direct experiment. Such an experiment, to have practical importance, must determine, not merely the extra yield obtainable by the use of a particular manure, but the relation between the amount of that extra yield and the amount of manure required to produce it. It may be very desirable to produce an extra yield of 10 maunds of wheat per acre, but if we have to expend Rs. 100 on the purchase of the manure necessary to accomplish that feat, we will be well advised to be content with the lower yield, for the value of the extra 10 maunds will be only Rs. 50.

The first stage in any scheme of manurial experiment will, therefore, be to determine the most economic application of each of the essential elements, and, as these are usually available in different forms, the scheme will include the commoner forms in which each element is available. Thus, nitrogen will be tested when applied as nitrate, as ammonia, and as combined nitrogen in cakes and in farmyard manure. Let us consider a simple series of experiments in which nitrogen is applied as nitrate in dressings equivalent to 5 lbs. nitrogen per acre to a crop of wheat. The result of such an experiment, using the system of scatter plots already described, will be somewhat as follows :—

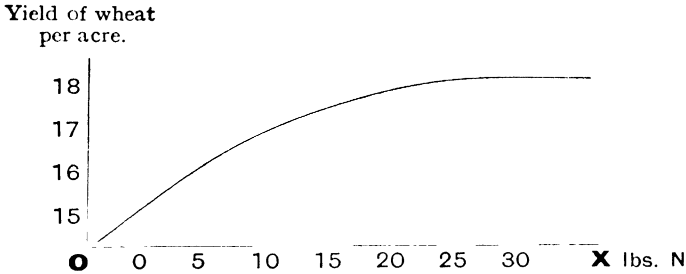
No manure	yield	15 mds.
5 lbs. nitrogen per acre	,,	16¼ mds.
10 lbs. nitrogen per acre	,,	17 mds.
15 lbs. nitrogen per acre	,,	17½ mds.
20 lbs. nitrogen per acre	,,	17 7-8 mds.
25 lbs. nitrogen per acre	,,	18 1-8 mds.
30 lbs. nitrogen per acre	,,	18¼ mds

The main feature of this result is that the addition of equivalent amounts of nitrogen does not produce equivalent increases of yield ; in fact, there is a gradually diminishing return from each successive increment in the supply. It follows from this result that, if the price of nitrate containing 5 lbs. of nitrogen be equivalent to the value of 10 seers of wheat, it will not be desirable to use more than the equivalent of 20 lbs. nitrogen per acre for the reason that the difference between the outturn from 20 and 25 lbs. nitrogen is 10 seers only, that is of a value equal to the additional expense incurred.

We have here an example of what is known as the law of diminishing return, a law of very wide application. As an example of that law, we may take the working hours of a labourer. If we check a labourer's output, and this can readily be done in the case of mill labour, we find that, after a preliminary brief interval spent in getting into the swing of the work, his output will reach a maximum, and that he will maintain that output until fatigue begins to set in. Subsequently each half hour's extra work will yield a lower output until it becomes more economical to close down the work, for the value of the diminished output becomes less than the cost of production. The same applies to mental labour, though this is not so readily measured. The length of hours in a school is determined by the average capacity of the students for continued concentration. An extra hour's work would, no doubt, lead to a slight increase in the knowledge acquired, but that increase would be attained with too great an effort on the part of the student.

The action of the law of diminishing return is best illustrated diagrammatically. If, on the line OX, we measure equal distances to represent equal increments of the causative factor,

and from each of these points mark off vertical distances proportional to the resultant outturn and join the points so obtained, we get a curve which ascends steeply at first, gradually rounding off till it becomes practically parallel to the line OX.



The diagram illustrates such a curve, and is based on the figures already given in discussing the relation that exists between yield and successive dressings of nitrogen as nitrate.

A similar set of trials is also possible with other manures, and a general idea will thus be obtained of the relative requirements of the land for the full development of the crop. Commonly, the combined effect of two, or more, manures is also tested and the desirability of making such combined tests rests on another consideration. We may suppose that we are testing a soil deficient in both nitrogen and phosphorus, but fulfilling in all other respects the requirements for plant growth. Development will here take place until the deficiency of nitrogen or phosphorus, let us suppose nitrogen—for which of the two it is will depend on the relative degree of scarcity—checks the growth of the plant. An addition of nitrate will, in these circumstances, stimulate further growth until, if sufficient nitrate be added, the deficiency of phosphorus comes into play as a check to growth. We have here an example of the action of limiting factors to which reference was made earlier in these lectures. In the circumstances a series of phosphate dressings, without nitrate, will show little, or no, benefit, not because the soil carries an excess of soluble phosphorus compounds, but because the limiting factor is provided by the nitrogen present

in the soil. A combined dressing alone will satisfy the full requirements of the plant.

We are now in a position to consider a scheme for manurial experiment, and we may draw up one to include the three more important elements, nitrogen as nitrate, phosphorus as superphosphate, and potash as sulphate. We must determine a unit increment for each element. This difference we will represent in lbs. by "a" for nitrogen, "b" for phosphorus, and "c" for potassium. We will also adopt a basis of 5 dressings in each case. Our series will then consist of the following :—

(1) 5 plots nitrogen only a, 2a, 3a, 4a, 5a lbs. N. per acre respectively
(2) 5 plots phosphorus only b, 2b, 3b, 4b, 5b lbs. P per acre respectively.
 5 plots potassium only c, 2c, 3c, 4c, 5c lbs. K per acre respectively.
(2) 5 plots a lbs N with b, 2b, 3b, 4b, 5b lbs P per acre respectively.
 5 plots 2a lbs. N with 2b, 3b, 4b, 5b lbs. P per acre respectively.
 5 plots 3a lbs. N with 2b, 3b, 4b, 5b lbs. P per acre respectively.
 5 plots 4a lbs. N with 2b, 3b, 4b, 5b lbs. P per acre respectively.
 5 plots 5a lbs. N with 2b, 3b, 4b, 5b lbs P per acre respectively.
(3) 25 plots similar to (2), but for N and K without P.
(4) 25 plots similar to (2), but for P and K without N.
(5) 5 plots a lbs. N, b lbs. P and c, 2c, 3c, 4c, 5c lbs. K respectively.
 5 plots a lbs. N, 2 b lbs. P and c, 2c, 3c, 4c, 5c lbs. K respectively.
 5 plots a lbs. N, 3b lbs P and c, 2c, 3c, 4c, 5c lbs. K respectively.
 5 plots a lbs. N, 4b lbs. P and c, 2c, 3c, 4c, 5c lbs. K respectively.
 5 plots a lbs N, 5b lbs. P and c, 2c, 3c, 4c, 5c lbs. K respectively.
(6) 4 groups of 25 plots each, similar to (5), but with 2a, 3a, 4a and 5a lbs. N respectively.

We have here a total of 215, or, if we add an unmanured plot, 216 plots, when to this is added a scatter system, in which each combination is repeated some five or six times, the number clearly becomes unwieldy. Further, such a series includes each element in only one of its available forms; a further complexity would have to be added, therefore, if we desired, for instance, to test the relative efficiency of nitrogen in the form of nitrate, ammonia or cake. Drastic reduction has to be made in the number of plots, and the direction in which that reduction will be made will depend on the extent of our prior knowledge of the soil and its general requirements. Whatever modifications the necessity for such reductions may introduce, the underlying scheme of any set of manurial experiments remains as we have described it. It will include the two

essential points, dressings in various combinations and in multiples of a unit chosen for each element of plant food, and a scatter system. Frequently that system is reduced to a duplication merely, each combination occurring twice only in the series. Under such circumstances the experimental error will be high, and it will be found necessary to repeat the experiment for a number of years before any reliable inference can be drawn.

The directed method of determining the value of improvements is, from the above brief description, clearly not an easy or simple one. It requires skill in designing, and even greater skill in the interpretation of the results. It is work which can only be undertaken with any prospect of success on farms especially designed and equipped for the purpose.

Chapter XXIX

AGRICULTURAL POWER

In the course of our discussion on the subject of agricultural improvement, we have indicated several desirable methods of procedure which come under the general head of cultivation. Ploughing the soil, interculture of the crop, and such like processes imply work, and work implies the consumption of power. And, inasmuch as ploughing to a greater depth, more frequent ploughing and more frequent interculture mean more work, the adoption of such methods implies a greater consumption of power. The cultivator requires a source, and an expanding source, of power. The question of the available source of power is an important one, and one which we must now study.

The limits of human power are originally given by the bare hands and feet, but, from the earliest times, man has learned to fashion implements which enable him to put that power to more effective use. With the "khurpa" he can weed his field, and with the "phaora" he can dig his field, much more efficiently than he could with his bare hands. The next stage in the progressive development in the use of power was taken when he learned to domesticate animals. By this act man had become possessed of a source of power many times greater than his own body is able to yield, and, with that possession, we find a development of implements, such as the plough, the patha, and so on, whose use is adapted to the greater power of the bullock. Throughout Northern India at the present time that is the limit of evolution in the application of power attained. Practically the entire agricultural work of the country is now effected by bullock or man-power. In other countries this is not so. In America, for instance, large areas of many hundreds of acres are worked by the smallest number of individuals, and mechanical power is called in to their aid.

We have to consider the possibility of developing that increase of available power which is necessary if improved methods are to be embodied in the general practice of the country.

We can recognise two classes of improved methods. The first we may illustrate by increasing the number of ploughings. The present unit of power is, here, capable of doing the work, and it is merely a question of the number of hours that can be worked, clearly a limited figure in the case of cattle which, in common with all living organisms, suffer from fatigue. In the present case the limit imposed from such causes can be removed by increasing the number of units, that is, the number of head of cattle kept to work the particular area. The second class we may illustrate by the substitution of an inverting iron for a desi plough. The former not only displaces a larger amount of soil, but it inverts that soil as well, while the desi plough merely displaces the smaller quantity. The iron plough consequently absorbs more power in its use unless the furrow is unduly narrowed ; it requires a stronger team of cattle. The difference is of the same nature as that between the phaora and the desi plough—the unit of power must be greater. The smaller power unit cannot make good the deficiency by working a longer period, nor will increasing the number of units avail.

In the first case the limit is not a mechanical one ; it is economic. An increase in the number of cattle means increased expenditure in the purchase of that larger number and in the cost of the extra food consumed, and it may be found that the extra cost of purchase and maintenance exceeds the value of the increased produce obtained as the result of their employment. In the latter case the limit is a mechanical one. We require here to ascertain the possibility of obtaining a larger power unit. Two methods suggest themselves, the possibilities of both of which must be considered. We may increase the value of our power unit by improving the class of cattle, or we may discard animal power and have recourse to mechanical power in the form of a steam or oil engine.

The bullock, which forms the present source of mechanical power, is an organism, and, as such, is liable to be affected by his environment in the same manner as we have seen the plant

in the field to be affected. He will develop his full power only when well nourished and carefully tended at all stages of his growth. Can it be said that the working cattle of the countryside are so attended? Hardly with truth. During the hot weather the cattle are commonly turned out to gather a precarious subsistence from the withered growth that remains in the parched fields and waste lands. In times of famine their condition becomes deplorable. This seasonal alternation of plenty and famine is not calculated to build up a robust body, and the ill effects are particularly marked in the case of young stock. The introduction of a fodder crop to supply green food throughout the year, leading up to stall-feeding, is an improvement that requires urgent attention in any scheme aiming at the general improvement of the stock of the country. Were this adopted for the young stock only, the effect would be appreciable, for starvation in the younger stages leads to constitutional weakness which may persist through life. The same result arises from working young stock at too early an age. In both directions the present-day practice is far from ideal, and the result is evidenced in the comparatively low efficiency of the average bullock as a power unit.

Yet another aspect of the question arises from the fact that cattle are organisms, and bear the attributes of such. They are subject to the same laws of inheritance as we have seen to hold good in the case of plants. Chief among the considerations that follow from this fact is this, that the male is as important as the female in determining the character of the offspring. Provision of a suitable bull is of vital importance; yet the whole system of the country, which leaves the entire work of service to chance, is opposed to any improvement in the direction we desire. There is an immense field of useful work in the development of breeds of cattle based on pedigree stock in which the same attention is given to the bull as to the cow. How important a matter this is, is in some degree indicated by those countries in which the raising of pedigree stock is undertaken as an industry. A good English pedigree bull will sell for as much as Rs. 30,000, for the influence of the bull in forming the young stock is fully appreciated.

From the direction in which we have approached the subject, our main object is to point the way to the improvement of the working cattle of the country. But that is not the only direction in which improvement of the live stock of the country can be effected. The value of cattle lies not only in the bullock as a worker, but in the cow as a supplier of milk. Here, too, considerable scope for improvement exists: and here, too, the importance of the bull must not be overlooked, for, strange as it may seem, the entirely female character of milking capacity is largely inherited through the male parent.

There is, thus, ample scope for the improvement of the type of working cattle, and for the evolution of one which is capable of developing the larger power unit we desire. But we must not forget that, while this is true of a large portion of the United Provinces, there do exist in certain tracts, as well as outside those Provinces, more or less definite breeds such as the Kosi and the Hansi, which already go a long way to satisfy our requirements for a larger power unit. We require, therefore, some explanation for the fact that these breeds are limited to certain tracts and not more universally used.

Let us consider a bullock for the moment from the mechanical aspect. By the consumption of a certain amount of fuel, represented by food, he develops a certain amount of energy, a portion of which is put to productive use by the owner. But since he is a living organism, his consumption is very largely independent of that productive use, for, while a minimum daily consumption is necessary to maintain a healthy condition, work will be usually intermittent only. Now the development of a perceptibly more powerful animal implies a larger body, and, for the proper nourishment of that body, a greater daily consumption of food will be necessary. The increased cost of this item has to be set against the revenue derived from the extra efficacy of those agricultural processes which are more effectively carried out by the stronger type of cattle. The calculation is not a simple one ; to make the comparison it is necessary to adopt simultaneously, not only the increased power unit, but the implements and the system of cultivation which can make use of this additional power to the full. The

first essential is capital to buy the cattle and necessary equipment, and few cultivators possess the necessary capital. The slowness of progress in this direction is due, thus, very largely to economic causes, and is no proof that, if capital were forthcoming, the adoption of a higher power unit would not be profitable.

We may now consider the possibility of the use of mechanical power in agricultural development. The engine possesses this advantage over cattle as a source of power that the consumption of fuel is limited to those periods only during which the engine is running. On the other hand the capital cost of any engine is relatively large, and its range of efficiency is small. By this last expression we mean that an engine designed to develop, say, 10 h.p. will attain its maximum efficiency, that is, will give the maximum return of work for the fuel consumed, only when taking a 10 h.p. load, and will give a rapidly diminishing return of work for the fuel consumed both with increased and diminished loads. It will be uneconomic to use a 10 h.p. engine to do work which involves merely a 5 h.p. load. It is impossible, in practice, to standardise agricultural operations to a definite load, and the alternative is, therefore, to run the engine uneconomically or to sink large amounts of capital in engines of varying capacity. But before we dismiss the use of mechanical power as impracticable, we may glance at the question from another aspect.

The work of a farm is seasonal, being greater at some seasons than at others. Throughout the plains there is, during the early months of the year, little work requiring power, for the crops are in the fields and are growing. In this matter the different tracts differ, for a considerable amount of power is required in the cane-growing tracts for crushing the cane, and, in well-irrigated tracts, the chief item will be the power expended on lifting water. With the harvest comes a great increase of work, for the crops have to be cut, usually by manual labour, carried and threshed, for which latter process cattle are usually employed. If, too, the system of hot weather ploughing be adopted, the lands must be ploughed, and for this cattle are required. This accumulation of labour occurs at a time when

the available supplies of cattle food are at their lowest, and the work which can be obtained from a pair of cattle is at a minimum. As the hot weather passes and the grain is threshed and stored the work tends to diminish, but, with the arrival of the rains, the sowing of rains crops and the preparation of the lands throws a new demand on the cattle power available, while yet another demand develops at the end of the rains for the preparation of the land and for sowing the rabi crop. In this seasonal succession of spells of high, alternating with low, demand, undoubtedly that demand is severest which arises at the time of the rabi harvest. Clearly, the cultivator who possesses the reserve of power which permits him to thresh his crops, to plough his land, and, in irrigated tracts, to prepare the land for early sown rains crops, will, at other seasons, have a large reserve of power on his hands which, if it be in the form of bullock power, means heavy charges for fodder. Mechanical power, if it is to come into favour for agricultural purposes, must, therefore, take the form which will offer relief at this season. The cultivator will then be in a position to keep only the number of cattle necessary to do the work of preparing lands for rabi sowings, and such reduction will mean a reduced fodder bill. This, again, means a reduced fuel bill, for the fuel charges for mechanical power are only incurred when the engine is running, that is, during the period of high pressure of work.

Mechanical power will, thus, reduce the annual fuel bill, and, to this extent, its adoption will be an appreciable gain, but, as we have seen, the capital cost is considerable. We have to see how the question is affected thereby.

We may suppose the capital cost of a suitable engine to be Rs. 5,000. If we allow this engine a ten years' life, allowing for interest and depreciation, we must obtain work from it equivalent to at least Rs. 750 per annum to meet the capital charge alone. This sum, too, must be forthcoming whether the engine runs for a few days only or practically continuously throughout the year. To this cost must be added that of running, and this latter will be proportional to the time run. Suppose now the work done in one day represents a sum of

Rs. 10 over and above the running charges. It will be necessary to run the engine for seventy-five days before the capital charges are met, and the advantage derived from its use will only begin to appear after that period. Subsequently the gain derived will be directly proportional to the number of days run above seventy-five. To derive the maximum use from mechanical power, therefore, it is necessary to find profitable use for as long a period as possible.

Of the power-consuming processes during the rabi harvest the chief are reaping, threshing, ploughing and preparation of the land. Of these, all except the second are unsuited to mechanical treatment, for the intense sub-division of the land into small units of cultivation renders the use of mechanically driven implements unprofitable. If, therefore, mechanical power is to come into favour as a substitute for cattle power, it seems inevitable that it must take a form adapted to thresh the crop, thus liberating the cattle for ploughing. The harvest, however, is not sufficiently prolonged to give a financial return on an engine which is used for this purpose only, and it is necessary to find other profitable uses by which the annual working period may be extended. In cane-growing districts there is a possible opening for running power-crushing mills, while, in well-irrigated tracts, the increased supplies of water derived from tube wells afford the necessary opening. The chief difficulty in the way of the introduction of mechanical power into the agricultural system of the country is not, therefore, a practical, but an economic one ; the provision of the necessary capital. The development of an improved agricultural practice is, thus, intimately bound up with the economic aspect, mainly the provision of capital, and this aspect will form the subject of our study in the following section.

PART V.

THE DEVELOPMENT OF AGRICULTURAL ECONOMICS

CHAPTER XXX

THE NEED FOR CAPITAL; FAMINE

IF we turn back to the earlier chapters in which the rise of agriculture was traced, we will be reminded that one of the main causes for change in agricultural conditions in recent times has been the development of lines of communication along which goods and food can be transported rapidly in large quantities and at low cost. The effect of the development of easy transport was shown to be twofold ; all limitation to the size of a city is removed, for food can be brought from any distance ; also the tendency is in the direction of localising crops, that is to say, in place of the cultivator growing small areas of a large number of crops, the tendency is for him to grow larger areas of one or at most a few crops only. That crop will be the one which will pay him best, and, with the money value received from its disposal, he will purchase those necessaries of life which he does not produce. Those necessaries may be grown in the neighbouring district or in the neighbouring provinces, or they may be grown on the other side of the globe ; the facilities of transport are such that it is often cheaper to import from the other side of the globe than to produce the particular product locally. The cotton, for instance, from which a large portion of the cotton goods used in India is made, is grown in America, sent from there to England, where it is spun and woven into the cloth sold in the Indian bazaars. Even Indian cotton, grown in India, is exported to Japan in large quantities ; there it is made into cloth, which is again shipped to India.

These are all effects of what we have termed the opening up of the world's markets. The price of any particular article no longer depends on the relation between the local supply and demand, but depends on the demand in a locality situated perhaps thousands of miles away. The importance of appreciating the full meaning of this recent change in agricultural conditions is so great that we may devote time to enter into the matter more fully.

By no facts is the result of this change made so plain as by a consideration of the subject of famine. Famine we are accustomed to in India even at the present day. Recent famines have occurred in 1897 and 1907, and we recognise them as periods of scarcity in which Government spends large sums in relief works and takkavi advances. These are famines in the days of facile communication, days in which the world's markets are opened up. But have we any conception of famine when communication was not facile, when the country side was dependent on its own resources, and when roads were so bad that limited quantities of grain and foodstuffs merely could be transported, and that over short distances only ? Let us try and realise a famine under those conditions.

Lower Bengal* is a country in which the rains are a practical certainty. It has three harvests in the year ; an unimportant and scanty pulse crop in spring, a more important rice crop in the autumn, and the great rice crop in December. It is a country with a dense population of many millions, who find their support in the crops which the unfailing rains produce with almost unbroken regularity. Unfortunately that regularity is occasionally broken, and, as happens when such occurences are few, the effects are all the more severely felt. Such a failure of the rains occurred in 1769 throughout lower Bengal at a time when railways were non-existent and roads few and bad; and the history of this famine, the records of which are very complete, will afford us some idea of what famine could be.

In the early part of 1769 prices ruled high; but the earlier

* This account is abbreviated from Sir W Hunter's fascinating book, "The Annals of Rural Bengal," published in 1868.

rains of that year were good, giving a good September harvest. Subsequent rains, however, failed; and the December rice crop, which depended on them, withered, the fields of rice becoming like fields of dry straw. In April only a scanty harvest was gathered in, a harvest insufficient to make up for the loss of the main December harvest, and distress continued to increase at a rate that baffled all official calculation. "The marvellous and infinitely pathetic silence under suffering which characterises the Bengali was at length broken, and in the second week of May the Government awoke to find itself in the midst of universal and irremediable starvation. 'The mortality, the beggary,' they then wrote, 'exceed all description. Above one-third of the inhabitants have perished in the once plentiful province of Purneah, and in other parts the misery is equal.'

"All through the stifling summer of 1770 the people went on dying. The husbandmen sold their cattle; they sold their implements of agriculture; they devoured their seed grain; they sold their sons and daughters, till at length no buyer of children could be found; they ate the leaves of the trees and the grass of the field; and in June 1770 the Resident at the Durbar affirmed that the living were feeding on the dead. Day and night a torrent of famished and disease-stricken wretches poured into the great cities. At an early period of the year pestilence had broken out. The streets were blocked up with promiscuous heaps of the dying and the dead. Interment could not do its work quick enough; even the dogs and jackals became unable to accomplish their revolting work, and the multitude of mangled and festering corpses at length threatened the existence of the citizens."

In 1770 the rainy season brought relief, and before the end of September the province reaped an abundant harvest. But relief came too late to avert depopulation. The pestilences incident to the season were spread over the whole country, and disease continued until the end of the year. "Millions of famished wretches died in the struggle to live through the few intervening weeks that separated them from the harvest, their last gaze being probably fixed on the densely covered fields that would ripen only a little too late for them.

"Three months later another bountiful harvest, the great rice crop of the year, was gathered in. So generous had been the harvest that the Government proposed at once to lay in its military stores for the ensuing year, and expected to get them 'at a very cheap rate.' The season of scarcity had indeed passed. In 1771 the harvests again proved plentiful; in 1772 they were so superabundant that the land revenue could not be realised in consequence of the excessively low price of the grain."

The famine of 1770 was, therefore, a one year's famine, followed by three years of extraordinary abundance, when Nature exerted herself to repair the damage she had done. That she failed to do so, the records of the next thirty years mournfully attest. Plenty had indeed returned, but it had returned to a silent and deserted province. When cultivation commenced the next year (1771) it was found the population would not suffice to till the land. In 1772 the finest parts of the province are reported to be desolated by famine and the lands abandoned, and the failure of a single crop is estimated to have swept away in nine months ten million human beings.

Such is, in bare outline, the appalling history of famine in the days before communications were opened up. It is perhaps incredible to most of us, but, as a contemporary report states, it is scarcely possible that any description could be an exaggeration. But the interest of this description to us is not in the tragic misery it lays bare, but in the causes which led to this misery. Ten million human beings die of actual starvation, from the absence of the food which is essential for their existence. It is true that food occurs in abundance in the neighbouring districts; reports mention contemporary damage to crops by excess rains in the not-distant delta. It is true a certain amount of grain was imported into the famine tract, but the facilities for the transport of any sufficient quantity were totally inadequate. The deaths are due literally to the lack of the necessary food.

Let us compare this with one of the recent famines; let us say that in the United Provinces of 1907. Can we say that there was a single death from literal starvation? It is very

doubtful if there was one. The first effect of the failure of crops due to deficient rainfall is the rise in price of the staple food of the country, and the persons to suffer are those with small and irregular incomes such as the labourer. But we may first consider the effect of the rise in prices; wheat, let us say, reaches 7 seers. There are in India, and in countries outside India, on which India can, if need be, draw, large wheat-growing tracts in which the crop is not dependent on the rainfall of the United Provinces. In the west Punjab, for instance, the wheat crop is largely dependent on the canals, and consequently independent of the monsoon rains. There is thus always a large supply of wheat in the Canal Colonies, and a supply which is far larger than the local population can consume. The local price of wheat in the Punjab therefore is low. Let us suppose it to be 10 seers. A trader will now be able to buy wheat in the Punjab at 7 seers and sell it in Cawnpore at 10 seers, giving him 3 seers in every rupee as profit on the transaction. It is not, however, clear profit, for he will have to pay the railway charges from sources to destination and charges for collecting and delivery. It is the modern facilities of transport which make these charges relatively light that are responsible for the automatic movement of grain to the centres of scarcity. As soon as the price of grain rises sufficiently in one locality to make it possible to purchase elsewhere, and bring it to the centre of scarcity, even from the other side of the globe, a steady flow of grain towards that centre will arise. There is now in India no large area so far removed from lines of communication that grain cannot be poured in if scarcity arise.

At first sight, then, it is not easy for us to understand the meaning of famine at the present day if scarcity cannot exist. We must remember, however, that food costs money, and that it is of little advantage to us if the bazaars are full of grain if we have not money wherewith to buy it. This is the true famine condition of the present day. There is a rise of price of the necessaries of life, a rise which will continue until it is sufficient to cause a flow of those necessaries to the area of scarcity. But accompanying this rise of price is a reduction in income of a large portion of the population. Owing to the

absence of rain, large tracts remain uncultivated, harvest operations are reduced to a minimum, and, in general terms, the available work is insufficient to employ the large volume of labour that works for hire. The labourer, therefore, spends many days idle earning no pay. Even the cultivator, who reaps less than his wont, will have a smaller surplus to sell, and may even have to purchase if he is to feed himself and his family.

Famine to-day, therefore, though due primarily to local failure of crops and failure of the local supplies, is not due to actual shortage of the essential food, but is due to the absence in the general population of the capacity to buy the food that is there. Famine relief is no longer afforded by the supply of grain, the ordinary trade channels are capable of supplying all that is required ; it takes the form of the provision of employment by which those out of work are enabled to earn the money necessary to purchase the grain which is there.

We are not, however, concerned with the methods of famine relief as such, and we have only referred to the question of famine as it illustrates so clearly the changes which have been brought about by the introduction of lines of communication. The factors which influence the movement of grain are those which influence the movement of any form of produce ; as the demand increases the price rises, until it pays to import from those countries in which the supply exceeds the demand, and in which the price is consequently low.

India is a country in which the main industry is agriculture, and, as a whole, there is an excess of agricultural produce available for export, and large quantities of grains and oil seeds are annually exported. Other countries, such as Canada, the Argentine, and Australia, are also exporters, and the price of any particular produce is controlled by the demand in the country of import and by the supply available in the countries of production. The price of wheat, for instance, will depend on the demand in Western Europe, and on the magnitude of the crops in North and South America, Australia, Russia and India. The essential point that we have to notice is that the price of wheat in India, and for the matter of that of most other goods, is no longer fixed by the laws of supply and

demand in India, but on the relation between the demand in Western Europe and the supply in other countries beside India.

The first question a cultivator has to ask himself when he has harvested his crop is, how shall I dispose of this to the best advantage? Shall I sell it now, or shall I hold up the produce in the hope that I shall be able to sell at a higher price? To answer these questions, two things are necessary; knowledge to be able to determine with some degree of certainty whether the price will rise, and ability to continue to live without realising money by the sale of the produce. The former, as we have seen, requires an intimate knowledge of the economic conditions of other countries, for, if prices may rise, they may equally fall, and in this case the producer may lose when he hoped to gain. The latter is commonly possessed by but few cultivators. In the vast number of cases the cultivator has borrowed money against the crop which is still to be reaped, and he is compelled to dispose of his crop not only immediately, but also to the particular individual from whom he has borrowed. He is not even in the position of being free to sell in the open market. This is a condition which is summed up in the statement that the cultivator lacks capital; in other words he lacks the means of providing himself with the necessaries of life apart from the crop he has in the ground or has just reaped. The result is as we have stated; he is unable to make use of any knowledge he may have as to what the market for his produce is likely to do, and is driven to accept the best terms he can from the local dealer from whom he has accepted a loan. This lack of capital is a characteristic feature of the agricultural classes in all countries, and we shall have to consider it more fully; from what we have said it is clearly a fundamental weakness of the producer's position. When, and only when, this weakness is removed will the importance of the second factor come into prominence.

CHAPTER XXXI

SOURCES OF CAPITAL

BY means of the comparison between famine as it was before and famine as it now is, after the introduction of means for rapid and cheap transportation of food, we have seen the effect that that introduction has had on the economic condition of the country. That effect is not limited to articles of food only, it holds with every form of product made use of by man. To reap the benefit of these conditions the producer, as we have seen, requires two essentials : knowledge of markets by which he may judge when to sell his produce; and capital, by which he is enabled to choose his own time for selling. He requires a third essential which we must now consider.

We have seen the condition of Bengal in 1770 during the famine. Under such conditions it is practically impossible to buy food for money. No individual has an excess, and no individual will part with that on which he depends for his life, however much he is offered in ready money, for no amount of wealth will serve him if its acquisition means his own death. At such a time food may be said to have no money value, for no one will part with it for money. Within almost a twelvemonth this famine was followed by abundance ; such an abundance that every person had as much as, and more than, he required for his own use. Again, food may be said to have no money value, but in an entirely different sense. In the present case it has no value because there is no one to whom the possessors can sell their excess supply. In the absence of means of transport it is, thus, possible that there may be two districts within relatively short distance the one of the other, in the first of which grain is without price from scarcity, while in the second it is without price because of its abundance. But such a condition can only occur when the difficulties of transport from one to the other are unsurmountable.

When means of transport exist between the two localities the rise of price in the region of scarcity and the fall of price in the region of abundance will cause a difference in price which

will enable purchases to be made in the latter region for despatch to the former where the greater demand has given rise to an enhanced price. There will thus arise a flow of produce to the region of scarcity, but this flow will only commence naturally when the difference of price is sufficient to cover the cost of transportation. Consequently the cheaper the charges for the conveyance oi produce the sooner will such a flow arise.

It is necessary, therefore, that we should form some idea of the factors which control the cost of transport. It would take us too deeply into the subject to consider why a particular factor produces a given result, and we must here accept the fact that it does so. The most important factor, and the only one which we shall have to consider further, is that of bulk. It will cost proportionately less to convey a thousand tons of any particular article than to convey a single ton. Subsidiary factors controlling the price are regularity in the traffic, whether a certain minimum traffic, can be guaranteed, as from the coalfields to manufacturing centres like Bombay; means of locomotion, (water transport is cheaper than land transport); and speed, of which we have a familiar example in the different rates charged for the same package according as it is despatched by goods or passenger train.

Of these factors, as has been said, the most important from our point of view is the necessity for handling produce in bulk. It constitutes the third essential to success in taking advantage of the economic conditions which have arisen from the introduction of facilities for transport, and we may now look at the position of the cultivator, who is the real producer of agricultural produce, and see how he stands with regard to these three essentials: knowledge of the markets, permitting him to judge when to sell; capital, permitting him to sell when he chooses; and bulk production, permitting him to take advantage of the concessions made in favour of transport in bulk. It will help us to understand the cultivator's true position if we consider the second of these items first.

What, then, is capital? What is this which gives a man freedom of action to determine when he will sell the produce he

has raised? In the simplest case a cultivator may have a hundred rupees buried in the ground, and, if the man to whom he offers his crop produce will not give him the price he considers reasonable, he may refuse to sell, and he is enabled to do so, because he can purchase his needs for some time to come with the hundred rupees. That sum, it is true, gives him the desired freedom of action, but it is not, as long as it is lying in the ground, capital. He may, however, instead of burying the hundred rupees, place it in the Post Office Savings Bank, when he will find, if he has kept it there a year, he can draw out a hundred and two rupees eight annas, or two rupees eight annas more than he paid in; in other words, his hundred rupees has, in one year, earned two rupees eight annas. As we have seen, money is merely a token and represents so much wealth, so that we can say that the sum placed in the savings bank is wealth used to produce more wealth. This is the essential feature of what is meant by capital; the idea of multiplication. Capital is wealth, but all wealth is not capital. As long as the cultivator keeps his hundred rupees buried, it is merely wealth; but as soon as he employs it, even if he uses it to provide himself with his immediate necessaries only, it becomes capital. We have assumed that he is using his hundred rupees so as to avoid selling produce at a price he considers too low. This is merely another way of saying that he hopes, by refusing to sell now, to be able to get more for his produce later, and in that case the difference between the price he would obtain by immediate sale and the price he actually realises later may be considered to be the sum earned by the hundred rupees. This sum is, therefore, capital, as it is used to produce more wealth.

Capital, then, is merely productive wealth, and is obtained in the same way as wealth. We may become possessed of wealth in many ways; our father may die and leave us the wealth he was possessed of at his death, in which case the wealth is inherited; we may break into someone else's house and remove valuable property, a method of acquisition we would not recommend; or we may borrow wealth from a friend. By whatever method we acquire that wealth, it will depend on the use to which we put it whether it becomes

capital or not; and if we decide to use it as capital, we have the fourth method in which we may become possessed of wealth. But we can only use this method if we are already in possession of wealth which we can use as capital.

It is frequently the case that our need for capital will arise at a time when we have no immediate source on which to draw for our needs. Our parents or rich relations do not necessarily die at that particular time, and, as we have seen, it is not desirable to satisfy our needs in this respect by theft. The only means open to us, therefore, is to borrow. To do this we must find someone who possesses wealth which he does not want at the moment to employ and who is willing to lend it to us.

Such a transaction may take various forms. The man from whom we borrow may be a friend who says, when we ask him for the wealth we require: "Here it is; don't bother to return it." Such friends are not common, and this method of acquiring capital is too unimportant to enter into our discussion. More common is the man who answers: "Here it is, let me have it back when you no longer require it." We have passed from the gift to the loan, but the transaction is still not a business one, and is based on friendship. It, too, does not enter into our discussion. We come, thus, to the third form, to the man who says: "Yes, I can let you have it, but what will you give me for the use of the wealth I lend you?" Here we have reproduced in the case of capital the conditions which we have already seen to hold in the case of other commodities. One man desires to possess a commodity and another will dispose of it if he thinks it will pay him to do so. The possessor of wealth may expend it in the satisfaction of some desire, or he may employ it himself as capital. If he lends that wealth to us he will have to forego that desire or refrain from using that capital himself, and he naturally requires some recompense for the loss; and it is, considered as a business transaction, merely a question of whether we can make it worth his while to do so. That will depend, in the first place, on the magnitude of his desire to use the wealth himself; and, in the second place, on the intensity of our desire to possess that wealth.

We have been led by the course of our discussion, to

consider capital in the form of money, and a loan as a loan of money on which a money interest is paid. As we have seen more than once before, however, money is, in itself, of little value; it is no essential part of the transaction that it should be in money, and one or both stages may be, and, in the case of the cultivator, frequently are, in kind. Thus he may find himself without sufficient grain to feed himself and family till harvest time, and he may borrow 5 maunds grain, promising, at harvest in two months' time, to pay back 6 maunds, that is, interest at a rate of 10 per cent. per month or 120 per cent. per annum. Or he may borrow 150 rupees to buy a pair of cattle under promise to pay back at harvest six months later 8 seers of grain for each rupee borrowed. Here the rate on interest cannot be calculated, as it will depend on the price of grain at harvest time.

We have illustrated the essential features of a dealing in capital by a very simple example of two persons, one of whom possesses wealth he has no great desire to employ personally either as capital or to satisfy some desire, the other of whom sees an opportunity for producing wealth, but lacks the necessary capital. The rate of interest is determined in this case by the relative intensity of the desires of the two persons concerned. That, however, is not the usual condition of a business transaction involving the loan of capital. Just as there is a market for a commodity such as wheat in which the price of wheat is determined by the eagerness with which the possessors as a body desire to sell in relation to the eagerness with which the purchasers, as a body, desire to possess; so there is a market for capital in which the price, or, in other words, the interest, is determined by similar causes. We may repeat this briefly in the form that the price of capital, like that of other commodities, is controlled by the usual laws of supply and demand.

We are thus concerned with cultivators' need for capital, a commodity for the supply of which there is definite market, and we are, therefore, concerned with the relation of the cultivator to this market.

Chapter XXXII

FACTORS GOVERNING CAPITAL LOANS

We have defined interest as the price of capital. This is, in a sense, true, inasmuch as the rate of interest is, like the price of a commodity, determined by the laws of supply and demand. This, however, is only one aspect of interest, and we must look at the subject a little more closely if we are to understand the bearing of our discussion on the development of agriculture.

We have seen that a transaction in capital differs from a simple purchase of a commodity in that, while the former is capable of immediate settlement in cash, the latter, of necessity takes the form of credit. The man who sells a maund of wheat is satisfied if the purchaser places the price of that wheat on the counter at the time of purchase, and he is not concerned to know whether the purchaser is the possessor of a fortune or, on the contrary, owes one. It is immaterial whether the purchaser is a resident of Cawnpore or Madras ; it is immaterial whether the money with which he pays for the wheat is legitimately acquired or stolen ; provided the cash is forthcoming the transaction can be completed as far as the seller is concerned. This is not the case with capital, as we would very soon discover if we were to part with some to the first man that asked us for it. We may consider the case of a man requiring a loan of Rs. 1000. Let us suppose that he goes to the bank and asks the manager for this sum. The manager will at once ask who he is, and, unless he is able to prove who he is and that he is a man of some standing, the interview will probably go no further. Let us suppose that that difficulty is overcome ; the manager will next ask for what purpose the loan is desired. If the loan is required for use as capital, that is for the production of more wealth, he will want to know details of the proposed

use and to satisfy himself that the proposal is sound from the business point of view. Ultimately he will ask him, who desires the loan, what guarantee he is prepared to offer that the loan will be repaid. Such a guarantee will be given by depositing with the bank title-deeds to the possession of land, share receipts and such like property which will enable the bank to recover the capital lent in the event of the borrower failing to pay the interest agreed on. If these difficulties are also overcome the loan will be made after the rate of interest has been fixed.

What is the essential feature of such a transaction ? It is this. When any transaction, such as the loan of capital, is entered into on a credit basis the seller always runs a certain amount of risk that he will not receive payment. The purchaser may disappear ; he may, when asked to settle the account, deny the transaction ; he may die before payment is made. Whoever the purchaser may be, the one thing certain is that the seller has disposed of his goods, and, until full payment is made, that seller is running a risk of loss of those goods for no payment at all. The risk may be great, as it would be if we gave a hundred rupees to a stranger who stopped us in the street to ask for the loan of that sum ; or it may be little, as in the above case, in which the bank hold documents by the disposal of which they can recover the value of the loan. But great or small, the risk is there, and we must recognise that it is an essential feature of all transactions in capital because they are, of necessity, credit transactions.

Risk, then, is the second item that has to be taken into consideration in determining the rate of interest to be charged. As the result of the laws of supply and demand a general rate of interest is determined which represents the interest which people expect to get for their money, or, in other words, which will attract people to lend capital rather than use it themselves. To this is added a sum, varying in amount with each particular loan, sufficient to cover the nature of the risk involved in each particular case. The former is known as the nett interest, and is fairly constant, though it varies, as has been said, in accordance with the laws of supply and demand. It is most nearly

represented by the rate on interest paid by Government on capital raised by loans, for the risk involved in a loan to Government is, generally, negligible. In actual figures the rate of nett interest varies between 2½ and 6 per cent. The latter is usually called a gross interest, and is very variable, because the risk is variable.

We have now to consider the third item which influences the rate of interest, and we shall understand this best if we revert to what we have already said about the advantage of dealing with commodities in bulk. Capital, as we have seen, is a commodity, and the price of capital, which is represented by interest, is reduced if it is handled in large sums, though the causes are in this case somewhat different from those we have considered when discussing the advantage of bulk transactions. Earlier in this lecture we have seen that the man who goes to the bank for a loan has first to establish his identity before the manager will consider the subject. Clearly it will be much easier for the bank to satisfy themselves of the truth of his statements if he is a wealthy trader or a large zemindar than if he is a villager from a small village out in the district. In the former case the loan will probably be some large sum, and, in the latter case, a few rupees only; but the size of the loan is not the only, or, indeed, the chief point. As we have described it, the ultimate responsibility for ascertaining the truth of the prospective borrower's statements as to who he is rests with the bank, and this involves some system of enquiry which will be, as we have said, easier, and therefore less costly, in proportion to the wealth of the individual. This cost of enquiry, in that it has to be paid for, and covered by, the interest of the loan, constitutes the third item influencing the rate of interest. It, too, is not constant, but it neither varies, like the nett interest, in accordance with the laws of supply and demand, nor, like what we have termed the gross interest, with the individual loan. Most institutions, of which the business is money-lending, have specialised in a particular line of business. In some of these lines the cost of enquiry will be greater than in others, and the addition to the interest to cover that extra cost will have in such cases to be

proportionately greater. This, together with risk, may be considered the two causes for the difference between the nett and gross interest. It is usually omitted in discussions on the subject of interest because few banking institutions will make loans which necessitate any large expenditure on enquiry. Nevertheless, it is most essential that we should recognise its existence, for, as we shall see, it is the cost of enquiry that renders loans for agricultural purposes by the existing banking institutions practically impossible.

Let us consider for a moment the position from the cultivator's point of view, and we may assume the case of a small zemindar who desires the loan of five hundred rupees to complete the sum necessary to build a pukka well. Such a loan is clearly one of capital, as, by the water from the pukka well, he will protect his crops in dry years, and thus raise his average outturn. His land, we may suppose, is in a village 20 miles from the nearest town which possesses a bank. He comes into the bank, and will have some difficulty in the first place in proving his identity; having overcome that difficulty the question of the purpose of the loan arises, and he will have less difficulty in proving that the proposal to build a pucca well is a remunerative proceeding than in proving that he really intends to build that well; and, lastly, he will have considerable difficulty in providing guarantees for repayment which the bank will consider satisfactory. He may offer the well when built, or his pukka house, which has cost many times five hundred rupees in building. But the bank must ascertain that the house is there, and, even when this is proved, it has to be remembered that neither the house nor well is movable. The former is only of value to a person who desires to live where the house stands, and, if no one desires to live there, the house will be unsaleable, while the well is only of use to the man owning the fields commanded by it. To establish the identity of the client, to ensure that the loan was really expended for the purpose for which it was intended, and to ascertain that property offered as a guarantee really existed, a bank which undertook to make such loans would require a large staff of agents to make the necessary enquiries, and, as its success or

failure would depend on the correctness of such agents' reports, those agents would have to be trustworthy and paid accordingly. Added to this we have the generally unsuitable nature of the guarantee with the consequent large risk in its acceptance, and it is no longer hard to understand that the rate of interest must be, under such circumstances, very high. And if it is high in the case we have taken, which is that of a well-to-do small zemindar, it must be still higher in the case of the rayat, or tenant at will. If such a man desires a loan, he has no permanent home, as he may be evicted next season, and he has nothing beyond his cattle, his implements, and a few brass utensils which he can offer as guarantee. How high interest would have to be in such a case it is impossible to say. The very fact that banks with this object have not been established is sufficient proof that it would have to be so high that productive use of the loan would be impossible.

This brings us to the consideration of the factors which influence a man in deciding whether he will borrow money or not. For the present we may leave out of consideration loans made for unreproductive purposes such as feasts, marriages and such like. These are not loans of capital, for they are not reproductive. We may consider the case of the man desirous of putting down a pukka well. He calculates that the extra produce he will get from an acre per annum is, on the average, worth eight rupees after deducting the cost of lifting water. If the well protects fifteen acres, his extra income, as the result of building the well, will be 120 rupees. To build this well he finds it necessary to borrow a thousand rupees, and he now has to decide whether it is worth his while to do so. Having estimated the cost of building he has to determine how long he may expect to get an undiminished supply of water from the well. Supposing he fixes this as twenty years, the depreciation on the value of the well will be one-twentieth of a thousand, or fifty rupees yearly. To meet this and the interest on the loan he has the sum of 120 rupees, and it will not pay him to borrow the thousand unless he pays less than 70 rupees, that is, less than 7 per cent. as interest. The question of whether it will pay to borrow money to carry out

an improvement thus depends very largely on the rate of interest. In the above case, if he can borrow money at five per cent., it will be worth his while to do so; but if he cannot get it for less than ten per cent. it will be better for him to go without the well, as he will make a larger profit, although the yields are smaller.

If we look at the various practical proposals which have been suggested by our study of the scientific basis in which the art of agriculture has its root, we will probably be surprised to find in what a number of cases the cost is really the fundamental obstruction to their adoption. We have laid considerable stress on the advantage of ploughing the land immediately after the rabi crop is removed. We have seen that the advantages depend on purely physical effects, such as the absorption of the first rain; on chemical effects, the result of exposure to sun and air, as well as on biological effects leading to an increased development of nitrogenous plant food; but the effect is plain to the naked eye, and does not require knowledge of these facts for demonstration. The practice is adopted on all Government farms, and has been widely advocated; yet the number of cultivators who practise hot weather cultivation is few. If we look a little more closely we will see that the reason why the ordinary cultivator does not cultivate his land when the rabi is removed is not because he will not, but because he cannot. We have considered the seasonal distribution of work, and, from that consideration, have learned that the period of the rabi harvest is the season of heaviest pressure. The crops have to be cut and threshed and the grain harvested. This provides a full day's work for his cattle, and, by the time the work is complete the cattle require a rest. To plough the fields, in addition to threshing the harvest, would mean the employment of more power, the maintenance of a larger number of head of cattle to the same acreage, and consequently increased cost both in purchase and food supply. This the cultivator is unable to provide; that he is aware of the advantage of such ploughing is apparent on the rare occasions on which rain falls when the crop is on the threshing floor. Threshing operations then of necessity cease, the land is

softened by the rain, and every available plough is put on to the land until threshing can recommence.

That is one example, and such examples could be multiplied indefinitely. Why, for instance, do the cultivators use most of the droppings of their cattle as fuel instead of putting it on the land ? The cultivator knows full well the advantage of cattle droppings as a manure, but the droppings of to-day must be allowed to rot, and must be put on the land before the crop which will give an increased return from their use, is sown, and the return from those droppings when used as manure will not be forthcoming for a twelvemonth. Meanwhile fire for warmth and for cooking purposes is a necessity of the moment, and, in the absence of any other supply of free, or even cheap, fuel the cultivator consumes that which should go to enrich the soil.

In such cases it is idle to expect the cultivator to change his ways merely as the result of demonstrating to him and telling him that it is to his advantage to adopt such-and-such a procedure. We must go deeper and provide him with the means to do so. Give him the means, and we will probably find that he is as alive to the advantages as we are ourselves ; and, as we have said, the means may, in most cases, be summed up in the word capital, and capital at a cheap rate of interest.

Chapter XXXIII

THE PROBLEM OF AGRICULTURAL CAPITAL

We have arrived at the conclusion that the cultivator requires not only capital, but cheap capital, and we have further learned that he is not in a position to obtain that cheap capital in the ordinary money market by any direct means. For such capital as he requires he is dependent on the village money-lender, and we are now in a position to consider an ordinary agricultural loan in the light of what we have learned about the factors which control the price of capital as represented by interest.

The ordinary village money-lender lives in the village, and is an essential element in the village community. He possesses an intimate knowledge of the cultivators who form that community, and he is able to judge accurately of the character of each. He is able to judge pretty accurately, when he is approached with a view to a loan, whether the applicant really intends to use the money in the way indicated ; he is on the spot, and will see that the loan is actually so spent. Limiting his loans to members of the village community and its immediate neighbourhood he has, therefore, no expenditure which would come under the heading of enquiry. On the other hand he undertakes a considerable risk. It is true that his risk from fraud is slight ; the cultivator who has received a loan on the surety of his cattle and implements cannot dispose of these without the creditor's knowledge, but the individual loan as a rule has little tangible property behind it, usually too little to enable realisation of the full value of the loan if the borrower fails to meet the demand for interest when it falls due. The guarantee is small, and if, through death or some such reason, interest is not forthcoming, the original capital will frequently

be irrecoverable. A high proportion of bad debts must enter into his calculations, and allowance made for them in the interest charged.

There is another aspect which we have not yet considered, but which the money-lender has to take into consideration. From a certain sum of money he calculates he receives a certain rate of interest, but if a large proportion of his loans prove to be, if not irrecoverable, at least paying no return, he will have to make good his losses on this head by charging a higher rate of interest on the good loans. This he can do, and he will in the long run still obtain the interest he considers desirable on the total sum at loan; but it is only in the long run. If there is any considerable variation from time to time in the proportion of loans paying no interest he will have to retain a larger sum available to meet his own needs at a time when the money lying at loan without interest is large. The sum so kept will have to be added to the total capital employed on which he desires his return; it is itself drawing no interest, and its existence goes to swell the interest it is necessary to charge on the loans actually made. This is the position of the village money-lender. His clients are largely derived from the same class; they are all very intimately dependent for their welfare on agriculture, and they are all residents within a small area. On such an area the climate is uniform; in a bad season all suffer, in a good season all benefit; and the capacity of each of his clients will, therefore, be affected in the same way at the same time. For this reason also, therefore, the rate of interest he charges must be high.

On these grounds we would expect to find the rate of interest charged by the village money-lender high, and we must recognise that a high rate of interest is legitimate on the ground of risk. There remains the question of net interest, and of how the rate of this is determined. We may return to the case of the small landholder who requires a loan for building a pucca well. He goes to the village money-lender and asks him for the loan of 1000 rupees. The village money-lender promises the loan at 20 per cent. interest. Now the applicant knows that it will not pay him to build the well unless he can obtain

the loan at 7 per cent., so he refuses the terms offered. But where else can he turn to borrow the money, for the money market, as we have seen, is not available to him ? We have here illustrated the fundamental weakness of the cultivator's position. The laws of supply and demand presuppose competition among a number of suppliers for the trade created by the demands ; but here that competition does not exist. The cultivator must either accept the loan at the rate offered or go without. The village money-lender is only human, and he would have to be otherwise if he did not, under these circumstances, fix the rate of interest demanded on what he thought to be the maximum his client would pay, and that rate will be one which will divert the major portion, if not all, the profits to be derived from the construction of the well into his own pockets.

We arrive, then, at the conclusion that, while a high rate of interest is legitimate, under the present economic conditions of the village the actual rate charged is determined, not by considerations of what gives a reasonable return on the money loaned, after making due allowance for risk, but by considerations of what can be got. Such a system is, of necessity, unsuited for productive loans, for providing the capital required if agricultural development is to make any progress. That development depends intimately on the cultivator ; it is the cultivator, who, by his additional labour, will produce the increased return ; he will not give that additional labour, or go to the trouble of changing his ways unless he himself will reap some material personal advantage, and no one will blame him for his attitude. On this basis alone the present system is seen to be unsuited to development, but its disadvantages do not rest there. We may consider, what is far more common a case than that of the cultivator who desires to build a pukka well, the small cultivator whose supply of food or clothing is insufficient to carry himself and family until the next harvest brings in a fresh supply. We may call these articles necessaries, to distinguish them from the second class, which we may term desirables. When such an one goes to the village money-lender for a loan, he, too, has no one else to whom he can turn

for the loan. But, unlike the former cultivator, he is unable to make a calculation as to whether it will pay him to take the loan at the rate of interest demanded. He requires the money for the bare necessities of life, and must accept any terms offered. Under these circumstances the money-lender can, and often does, ask rates which he knows the cultivator can never pay, and which mean that from that time onwards all the profits above what constitutes the bare minimum for existence will pass to himself.

It is as well we should distinguish the two classes of money-lending: that which deals with the provision of necessaries, and that which deals with the provision of desirables. Money-lending which is concerned with the former, in which the profit, as composed of the interest charged, is derived from the exploitation of a person's necessities, is illegitimate, and is what we have termed usury. The point has been dealt with in an earlier chapter. Usury is recognised as illegitimate in all countries and by all religions, and the usurer is justly reprobated. Money-lending which concerns itself with the latter is legitimate, because the borrower is in a position to refuse the loan if the terms are not acceptable. This distinction derives its importance from our present point of view not so much from the moral aspect as from the light it throws on the rate of interest charged. If we have followed the arguments so far adduced we will understand that the rate of interest alone does not determine the legitimacy or the reverse of a transaction. A high rate of interest, even 100 per cent. per annum, may be legitimate in one case, while a lower rate, owing to the special circumstances will, in another, be illegitimate.

The conditions which exist in the village, then, are such that, at the worst, admit of the development of usury, and, at the best, render the cost of capital too high to make its employment for purposes of improvement in any way general. To obtain agricultural development a much more general employment of capital is necessary, and this will only be obtained by the cheapening the rate for capital to the cultivator so that he will have left over for his own use a liberal balance of profit, after paying for the loan, to recompense him for this

extra labour. We may look at this question of the cheapening of agricultural capital from two directions; from the point of view of removing the disabilities which prevent the ordinary banks from making advances and entering on such business, or from the point of view of widening the present bases of supply of agricultural capital. The former is mainly a question of removing risk, for our previous arguments have shown us that it is the heavy cost of enquiry and of the attendant risk that is responsible for the large difference that would legitimately exist between the gross and nett interest. The latter, on the other hand, is mainly a question of providing competition among those loaning money for the same demand. In both cases a further reduction in the rate of interest would result if a more certain form of guarantee were available. These are matters that we shall have to consider more fully later; at the moment there is one other aspect which we must discuss before we will be in a position to appreciate the direction in which the remedy is to be sought.

Capital, like any other commodity, has a market value, which is determined by the laws of supply and demand. The present market value is the point of equilibrium between the present capital available for loans and the present demand, which is chiefly industrial. If any sudden change takes place to disturb that equilibrium, either in any large increase or decrease in either supply or demand, a fresh point of equilibrium will be established about a new rate of interest; a decrease in the supply, or an increase in the demand, will lead to a higher rate of interest, while an increase in the supply and a decrease in the demand will lead to a lower rate being established. Now, if we have understood the cultivator's position rightly, his great need for progress is capital, and, though the amount of capital desired by the individual cultivator may be small, the total amount is enormous. Any large employment of capital for agricultural development will involve an appreciable increase in the demand, and, consequently, a corresponding rise in the rate of interest, a rise which is the very reverse of what is desired. For such employment of capital as we are contemplating, therefore, it is not merely necessary to reduce the

risk on the loan, to bring the agricultural loan under the laws of supply and demand and to strengthen the guarantee on which the loan is made, but it is also necessary, concurrently, to increase the supply of capital. Only so can the large demand for capital for agricultural purposes be met without a general rise in the rate of interest, and we must look about for a source of capital, which is not at present developed.

When the cultivator has disposed of his produce, he may find, if the season has been favourable and prices high, that he is the possessor of a small sum in cash which is over and above what he requires to satisfy his immediate wants. If he is thriftless, he may spend that sum in luxuries such as a dinner to his caste-fellows, in which case the sum is lost. If, on the other hand, he is careful, he may desire to save that sum against a season when he has bad luck ; when his crops fail, or his cattle die of disease. How can he keep that sum ? He may bury it in his house to be dug up only when a need for its use supervenes ; he may purchase jewellery with it for the adornment of his wife or children, knowing he can sell that jewellery if the need arises. In neither case will he receive more than the actual sum buried or spent in jewellery. The sum, however, small though it be, is wealth, and hence potential capital, and, if he can lend that sum to someone whom he can trust to return it to him when he requires it, he should not only receive the sum he lends, but that sum with interest, for it is now capital. Small as each sum of this nature is, the aggregate of such sums either buried or in the form of jewellery, is enormous, and they form such a potential source of capital as we are looking for. The problem is to collect these sums and render them available. That, as we shall see, is a matter of time ; a matter of exciting confidence in the possessor of that small sum that, if he parts with it, it will be forthcoming if he wants it.

The hesitation of the cultivator in parting with his small savings is perfectly natural. The country has not always been settled, and the time was when, to trust anyone with those savings, would have been equivalent to throwing them into the river and when the only chance was to reduce them to the

smallest bulk possible and hide them. But, even so, the hidden hoard may be found ; it runs a risk of growing less or disappearing, while it never can grow greater. Converted into capital it can grow greater, and, if this is accomplished under conditions which, at least, do not magnify the risk of loss, then the advantage lies to the cultivator in such conversion. The whole history of India, however, is one of disturbance in which, whoever lost or won, Rohilla, Moghul, Mahratta, French or English, the opportunity to loot was the main feature. It is not surprising, therefore, that the difficulty in converting the small savings, the hoarded wealth, of the cultivator into capital lies, not so much in the difficulty in finding a means, as in overcoming the just fear of the cultivator, just fear because it is the outcome of experience.

This, then, is the capitalistic problem, the problem of the provision of a supply of cheap capital for agricultural development. In its essentials it is the problem of reducing the risk, of raising the standard of the guarantee and of bringing the agricultural loan under the ordinary laws of supply and demand, by these means decreasing the rate of interest, while at the same time increasing the capital available for the purposes of such loans. Having arrived at a definition, we can now pass on to a consideration of the means of its solution.

CHAPTER XXXIV

THE PRINCIPLES OF CO-OPERATIVE CREDIT

ONE of the causes for the high rate of interest has been seen to be the inadequacy of the guarantee. Should the borrower die, the whole of his property may be insufficient to cover the amount of the loan, and the losses from such causes have to be made good out of the interest charged and realised on the remaining loans. But, supposing a cultivator, whom we may term A, pursuades two of his friends, B and C, to give security for him and to undertake to repay the amount of the loan, should he fail to do so, the guarantee is at once increased and the loan made easier. The chance that A, B and C will all die at the same time and the loan be irrecoverable from all of them is infinitely less than the chance that A alone will die, while the fact that B and C will be held responsible if A disappears in order to escape payment will make B and C take care to see that A does not disappear. Union to provide a joint guarantee therefore should lead to a reduction of interest, inasmuch as it not only renders the guarantee more adequate, but reduces the risk.

The arrangement we have described appears very satisfactory from A's point of view, but the advantage to B and C is not so clear ; the transaction is not a business one, if B and C give security merely as a matter of friendship. The advantage to B and C becomes apparent if we consider the agreement to become permanent. B, and ultimately C, may later desire loans, in which case A's security will be of assistance, and, even if all three require a loan simultaneously, it will be im probable that all three will repudiate their loans simultaneously. Thus, by uniting for the purpose of offering a guarantee, they will be able to obtain a larger credit than they would if they

were each to borrow independently. From such an association of three men we may pass to the association of an indefinite number united into the form of a society to provide the joint guarantee, and we may consider the essential points of such a society. Its main object is to procure credit at a cheap rate of interest by strengthening the guarantee and by reducing the risk from the point of view of the lender. Instead of being arranged with the individual, the loan will now be made to the society, and, if the joint guarantee is to be effective, it is clear that each and every member must be responsible for the entire value of that loan. The responsibility of a member of such a society under such conditions is only limited by the total amount borrowed, and the liability is said to be unlimited. Limited liability societies, that is societies in which the members are liable to be called upon to pay a fixed sum only, and one which they know the value of on joining, also serve a useful purpose, but, in that they reduce the magnitude of the guarantee, they do not carry, for agricultural purposes, the same advantage as is conferred by unlimited liability. The effect of such liability and the knowledge of his own responsibility in the case of a loan to a fellow member, M, will induce the cultivator we have termed A to be very careful, in the first instance, in admitting M into the society, and in the second instance in scrutinising any demand he may make for a loan. He will also take care to see that the loan, when granted to M, is expended on the purpose for which it was taken, and not spent on some other unreproductive manner.

This check of A on M implies, if it is to be effective, an intimate knowledge of M, both of his character and of his property, and such a society as we have outlined must be limited to a group of men who have such mutual knowledge one of the other. The members of such a society must, therefore, be drawn from a small area in which, alone, does such mutual knowledge exist. They are essentially village societies, the membership being limited to the occupants of a single village. Such societies form the basis of a system of credit which has developed of recent years, and which promises to go far in providing the cheap credit which we have seen to be so essential

to agricultural progress. The society is known as a co-operative credit society, and the system the co-operative system. It is a system, the history of which reads like a fairy tale. As we have already noted that lack of capital is not a feature peculiar to Indian agriculture, it is common to agriculture of all countries. It was a marked feature of the agriculture of Germany about the middle of last century when Raifeissen started his first co-operative society in which the entire system found its origin.

We must consider this system more closely and see how far it is effective in meeting the conditions which we have seen in previous chapters to be necessary to the supply of cheap capital. The essential conditions of the unit society, mutual knowledge and trust such as is only obtainable as the result of the intimacy derived from the mutual occupancy of the same village, and unlimited liability, have already been referred to. These give a greater assurance that the loan will be recoverable, but they do nothing to remove the second obstruction to the reduction of the rate of interest, namely, the failure of the laws of supply and demand to apply to such cases. The society is a village society, and, as such, can only apply to the village money-lender whose terms are not subject to these laws, and who, therefore, does not take the question of the guarantee into consideration in fixing the rate of interest. The first stage in the direction of providing a second source of capital and, subsequently, in the introduction of competition for the agricultural demand is in the organisation of what have come to be known as Central Banks. These, in reality, are associations of village, or, as we may term them, primary societies, and their capacity for borrowing money is determined by the sum of the guarantees offered by each of the primary societies. As the primary society borrows money on the united guarantee of all its members for the purpose of a loan to one of its members, A, so the Central Bank, on the united guarantee of all the primary societies which constitute its membership, is enabled to borrow to provide a loan to one of the affiliated societies. In this case, however, the mutual and personal knowledge that exists, and is the essential feature of the primary society, is not

possible, and the central bank is not in a position to enforce unlimited liability ; the guarantee for repayment of any loans made to it, therefore, are dependent on the knowledge that capital, so loaned, is passed on by it to the primary societies, the unlimited liability of which makes recovery of the loan certain. The Central Bank is, thus, an institution which combines in itself the sum of the individual guarantees of the members of the affiliated primary societies, and which, on the strength of that guarantee, is enabled to enter the money market for the purpose of borrowing.

Let us now consider the nature of the transaction between the ordinary bank such as we have seen constitutes the medium for lending money in the money market, and is the source of loans under the control of the laws of supply and demand, and the Central Bank. The bank is now in a position to deal with a single borrower in sums of some magnitude, that is, under conditions in which the cost of enquiry approaches a minimum. The main obstacle which prevents the individual cultivator borrowing from the ordinary bank is thus removed if the position of the Central Bank is easily ascertainable. Facility for such enquiry is given by two factors, proper systems of accounts and publicity. Both these factors are supplied by the registration which is insisted on. The Co-operative Societies' Acts passed by Government are acts for facilitating the formation of co-operative societies and for encouraging their development under conditions which will promote confidence in their financial soundness, and they insist on such matters as proper audit and publicity.

Even with these safeguards and provision for publicity, which all tend to reduce risk to, and facilitate enquiry by, the prospective lending bank, it is found that the central banks do not sufficiently bridge the gap between the primary society as borrower and the money market as represented by the ordinary "Joint Stock" banks and the tendency is for the central banks to unite in their turn and to form one central Apex Bank to which the several central banks are affiliated in the manner in which the primary societies are associated with the central banks. Such association tends to be restricted to the

political divisions of the country, and these apex banks have, therefore, been termed Provincial Banks; their object is, by a process akin to that we have described in the case of the central banks, to complete the bridge which brings the Primary Society into contact with the money market.

The system of co-operation, so far as we have gone, therefore, both diminishes the risk, increases the guarantee, reduces the cost of enquiry, and puts capital at the cultivator's disposal under terms approximating to those holding in the money market. But such a system is not built up and worked for nothing. The whole system is built up on a guarantee based on the aggregate of the innumerable small possessions of the individual who form the primary societies. Its soundness, therefore, depends on the actuality of the existence of those possessions. Now a cultivator may possess a pair of cattle, and those cattle form an item in calculating the value realisable from him in the event of the primary society being called on to meet its liabilities. But that pair of cattle has no such value if the cultivator has already, before joining the society, borrowed money from the money-lender against them. In these circumstances, were the society to attempt to realise on those cattle, the money-lender would immediately advance a prior claim. A full and accurate record of the exact financial position of every single member of the primary society is thus essential to the soundness of the entire co-operative structure. That record, known as the Haisiyat Register, is the foundation on the accuracy of which the superstructure depends for its stability. The expense so incurred, as well as the cost, which represents the risk which, though reduced, can never be eliminated, has to be met. The primary society borrows money from the Central Bank, which it has to repay, with interest, and that repayment must be made in full if it is not to go into liquidation. That money is now distributed among its members, and the risk involved means that some small proportion of those loans will be irrecoverable. These charges are met out of interest, the society will borrow money at, say, 9 per cent. from the Central Bank and charge its members, say, 12 per cent. In the same way, if the Central Bank can borrow at 7 per cent. it

will loan to its affiliated societies at 9 per cent., 2 per cent. being sufficient to cover the cost of organisation and the risk.

There remains one aspect to which our attention was drawn, the necessity for increasing the loanable capital, and we saw that the store of capital was to be found in what we termed, for brevity, the hoarded wealth of the country—that indefinite, but very large, sum made up of the innumerable small sums, held in cash or jewellery, by the millions of small cultivators who form the bulk of the agricultural population of India. If the co-operative organisation can convert this wealth into capital it will fulfil all the functions which we have seen to be necessary to the provision of cheap capital to the cultivator.

The custom of burying money, or of converting it into jewellery, owes its origin to the fear that it is not safe to part with possessions to anyone. It is a fear largely justified by centuries of disturbed conditions, and it is a fear which will only gradually be done away with. It is not probable, therefore, that the habit of lending savings will develop rapidly with the cultivator, but it is not possible to conceive a surer way of fostering that habit than the co-operative movement. The cultivator who is a member of a primary society learns to look to that society for help, he learns its methods, and he knows the individuals who compose it. After experience he ceases to regard it with suspicion born of ignorance, and perhaps, first, only by persuasion, but, later, of his own free will, he begins to deposit his small savings with the society; Now the primary society has to pay interest on any loan that it takes from the Central Bank, and, if the money which is required for this purpose can be raised from the savings of its own members which are deposited with it, the amount paid to the Central Bank as interest will be saved and be available for distribution among the members of the society. The central banks in their turn can receive deposits from those primary societies whose members' savings total at any time more than the value of their borrowings. In 1914, out of a total capital of 293 lakhs, over 145 lakhs were provided by the members of the primary agricultural societies, so that the practice of depositing savings has already attained

considerable favour, and there is, therefore, reason to hope that, as time goes on, the capital required will be largely provided from the wealth hitherto hoarded.

Such, in very brief outline, are the main features of the co-operative movement, and it is not possible here to enter into the subject more fully. We have approached the subject from a single aspect only, namely, as a means of providing cheap capital to the cultivator. That, it is true, is an important aspect of the movement, but, as a deeper study would show, it is not the only, nor, indeed, the most important aspect. It is essentially a movement of the people, for the people, and should be conducted by the people. When so conducted, its educative effect is great, and leads to a stimulation of that desire for knowledge which is at present generally lacking in the Indian rayat.

Chapter XXXV

THE PRINCIPLES OF CO-OPERATIVE SALE

We have considered at some length the question of capital, the provision of which is one of the essential needs of agricultural development. It is not, however, the only need. If full advantage is to be taken of the facilities for transporting produce, and if the profits are to accrue to the producer, it is necessary that the produce should be handled in bulk. Northern India, however, is essentially a country densely populated with small cultivators, each tilling a limited area from which the first endeavour of each is to extract food to feed his family and cattle. Economically, for this reason, India differs fundamentally from such countries as Canada, Australia, and the Argentine, which are countries of vast expanses thinly populated. The farmer in these, neither tries to feed himself nor grows a variety of crops. He is concerned with a single crop and with fields of 100 acres or more ; individually his production is in bulk, and he can sell in bulk. A brief study of the causes of this difference will assist us to understand the economic problem of bulk handling in a country of small units.

India is a country whose history and civilisation date back to remote ages, and the plains of Northern India especially have supported a teeming population for an indefinite length of time, and a population which has increased enormously within the last few decades. Of that period the later years, which are characterised by the development of roads and railways, constitute as it were but a few days. And this teeming population has arisen and developed a habit of life suited to a time of little outside intercourse, a mode of life which the sudden development of means of transport in recent years has done little to alter. Agricultural development, too, has received

the impress of adaptation to conditions now passed. Each family is the centre of production of its individual needs, and each village is an economic unit.

Under these conditions there was little need for the family to cultivate more land than will suffice after paying the rent to provide the family's wants and to pay in kind for the services of the joint village servants such as the blacksmith and carpenter. Any large surplus was unsaleable, because unexportable and not worth the labour of production. The small holding and system of mixed cropping are obviously the economic solution best adapted to the conditions, the drawbacks to which would not become apparent until the increasing population begins to place a strain on the productive capacity of the soil. So long as the possibility of extension of the cultivable area remains, an increase in the number of families as generation succeeds generation is not necessarily accompanied by a reduction in the size of the family holding, and it is only when this extension has reached its limit that either a reduction must take place in the size of the holding or a certain number of families must suffer alienation from the land. Which of these two takes place depends on the lines of social development, which in India, under the form of the joint family system, lead to a sub-division to which there is no limit, and a sub-division which, if proceeded with long enough, must clearly lead to an unit of cultivation totally inadequate to support the family.

This is the condition which prevailed in large tracts of India when the development of roads and rails, which characterised the end of the 19th century, produced a sudden change in the economic circumstances and rendered possible a large industrial development by which the means of earning an income has opened to a large bulk of the surplus population. Nevertheless, sub-division had already proceeded in certain tracts, as Bihar and the East of the United Provinces, to an extent which has reduced the holding to below the economic limit, and, owing to the innate conservatism and love of the land so typical of all agricultural populations, is still proceeding.

This development may be compared with the development

of a country like Canada—a country till a few years ago of rolling prairie and dense forest occupied by a few wandering tribes and bare of cultivation. Into this wild the rail and road are pushed, and settlers are attracted by the free gift of land on condition that they bring it under cultivation. The stimulus to cultivation is here from without. The development is in the direction of bulk production on large areas by the use of labour-saving appliances with the conservation of human labour. We have here a system which is the consequence of the facilities for cheap transport, and the problem is one of co-ordinated progress, a problem differing entirely from that which presents itself in India, which is the very much harder one of adapting a highly intricate system to the new economic conditions which have suddenly arisen.

It is hardly necessary to emphasise that the problem will not be solved by attempting to introduce any system of recombination of small holdings into larger ones. However desirable such a procedure may be, the history of agrarian disturbances in all countries should teach us that it is impossible to drive an agricultural population or to introduce any violent social changes such as a recombination of this nature would imply. There are only two practical courses, therefore; the one to check as far as possible further sub-division; the other to effect a recombination of the small units of production, the 20 or 30 maunds of wheat raised by the individual cultivator, into bulk lots of 1000 maunds or so, on which the advantages of bulk dealings will be obtainable, under conditions which will ensure the profits from the transaction accruing to the producer.

Any minute discussion of the first of these courses would lead us too far from our particular study. It is largely the concern of Government, by opening new tracts, in the way in which the Canal colonies of the Punjab have recently been developed, and arranging for the colonisation of these from densely populated areas and by fostering industries which will draw their labour from the excess agricultural population, that is by offering alternative means of livelihood, that further sub-division is to be checked; for it is unlikely that the economic disadvantage will lead to any revision of the laws of inheritance

which have their foundations in a religious basis. We may turn our attention therefore to the second course, the recombination of the many small units of production into a few bulk consignments.

It is impossible entirely to separate the subjects of the provision of the capital and disposal of produce as they are interdependent. We will have to revert to our discussion on the former subject if we are to understand the latter, for, as has already been explained, one of the functions of capital is to afford that freedom in the choice of disposal which is so necessary if full advantage is to be taken of the market. We may commence our study of the question of disposal by a consideration of the present system.

The cultivator in many instances has borrowed on the strength of the future harvest ; he may even have borrowed the seed necessary to produce that harvest. He will promise to pay at harvest time the amount borrowed plus a sum as interest. For instance, in the case of a loan of wheat for sowing, if he borrows 1 maund he may promise to pay back 1 maund 10 seers, representing, as the loan is for the period of the crop only, that is 6 months, an interest of 50 per cent. per annum. He may reap as the crop produced from that maund of wheat say fifteen maunds, of which 1 maund 10 seers represents his debt and interest on the loan of seed grain, 2 maunds his rent, and 1 maund his reserve for the next season's sowings (if he reserves this), leaving 10 maunds for the support of himself and family. With the average size of holdings the cultivator is unable to place a larger area under grain crops than will supply his needs if he returns the whole of the crop after paying off these dues, and, consequently, the excess grain available for sale in the town or for export beyond the province is represented very largely by the 10 seers per acre which is paid as interest on the loan of seed wheat. The important point for us to recognise is that this excess grain, on which the profit is to be made, passes to the capitalist before disposal in the open market, and that this profit therefore does not accrue to the producer.

The same result, though under somewhat different circumstances, is reached in the case of a crop like cotton, of which the

cultivator makes little or no direct use. At harvest time he probably requires money, and will dispose of the entire produce, trusting to borrowing the seed required to sow the next crop. He must take his produce to the dealer with whom he is accustomed to deal, and he must accept the rates offered by that dealer, or he will be met with a refusal when he next desires to borrow seed or when he desires a money loan. Here also the produce has passed to the dealer before the profit due to its disposal in the open market has been realised.

The remedy for this state of affairs is primarily to remove the necessity for selling seed which should be kept for sowing. This is the problem we have already discussed, the provision of cheap capital. That alone however, will not fully meet the situation. It liberates the cultivator and makes it possible for him to dispose of his produce in the open market, but the open market does not deal in the small quantities which he individually handles, while, in certain instances, the produce of the field has to undergo treatment before it assumes the form for which there is a market. This is the case with cotton; the kapas which the cultivator collects in the field must be ginned and the lint (rui) so obtained baled before it assumes a form which the market will handle.

Bulk production being out of the question, it will be necessary, if the object we have outlined is to be achieved, to collect these small units into combined lots and to submit these combined lots to any process necessary to fit them for the market before they have passed out of the possession of the cultivator. Such a process of combination of small units to form large ones is procurable by a form of co-operation which is, in principle, the same as that which we have discussed, namely, association for mutual benefit, in this case the benefit lying in the free disposal of produce in the open market.

Though the basal principles of such an association are similar to those of the co-operative societies which we have discussed, there are certain differences arising from the particular object for which they are instituted. We may refer to these as co-operative sale societies, and we may proceed to consider them briefly. Credit is only of value when cash is not available,

and it is not possible to purchase credit with cash. Credit societies are consequently built up on trust, the guarantee for which is provided by the mutual knowledge, and the unlimited liability of the individual members. The society is, in this case, usually the debtor. In the sale society the purchaser of the produce held by the society is the debtor, and, further, the produce can be disposed of for cash. There is thus no reason for that mutual knowledge and for that unlimited liability which we have seen to be the basis of the credit society. Capital sufficient to cover the expenses of handling the small units, of bulking them into suitable form for the market and of taking them to the market and a sufficient knowledge of the officers of the society to ensure that they are acting in its best interests, are all that is required. A share capital and limited liability are all that is necessary to finance such a society, while the members may be drawn from a less limited field than is desirable in the case of the credit society.

The co-operative sale society, thus, extends the sphere of utility of the co-operative movement, but it is subsidiary to the co-operative credit society, and its advantages can only be reaped by the cultivators who have that freedom of action in the disposal of their produce which is given by membership of a credit society.

CHAPTER XXXVI

ADDITIONAL OPENINGS FOR CO-OPERATIVE ACTIVITY

WE have considered two forms of co-operative societies, the credit society, which aims solely at supplying capital at reasonable rates of interest; and the sale society, which aims at turning to its own profit the advantages to be derived from bulk production, and, by the elimination of the middle man, at reaping the profits usually demanded by him for his intervention. Before leaving the subject of co-operation to return to our main line of argument, we may glance at certain other forms of co-operation which offer a means, though perhaps a less direct one, for increasing the cultivators' profits.

Co-operative sale mainly derives its value from the fact that it brings the producer into direct contact with the market and places the profits to be derived from such direct dealing within his reach. Normally the bulk rates in a market are lower than retail rates. That the actual cash value received is, consequently, relatively low, is true ; but the advantages of such dealings more than outweigh their disadvantages. In the converse case, that is, in the case of purchases, the low rates demanded in bulk, or wholesale, dealings are an added advantage and there is, thus, a considerable scope for co-operative purchase societies. For strictly agricultural purposes, owing to the small demand for external supplies, the field is at present limited ; but when such a demand does arise, as, for instance, would be the case if the use of artificial manures were generally adopted, such societies may become a common feature of the agricultural economy.

Under present conditions co-operative societies of a less determinate character are likely to have a more immediate scope, and we may proceed to consider a few of these before we leave the subject of co-operation. From what we have learned of the methods of plant-breeding and crop selection it is easy to see that the need for raising improved varieties and the production of seed sufficient to sow any appreciable area is considerable. As a commercial proposition, that is, as a proposition in which interest is expected on the money invested, it follows that such selected seed must be sold at a rate considerably above the market rate for the particular commodity.

Let us, for a moment, look at the business of a seedsman working along commercial lines. We may further limit our consideration to a single crop, let us say, wheat. His aim is to secure for disposal a bulk of seed of those varieties of wheat found most suited to the district in which his clients reside, and that seed he requires to be pure. He will, further, spend time and trouble in testing new varieties or even in experimenting in raising such new varieties. For that time and trouble, as well as for the actual expense incurred, he requires a financial recompense. Let us suppose that he has, by such means, developed a new race of wheat which shows superiority over the standard wheats in certain particulars. At first the bulk will be small. He will now multiply up that stock, and at the same time, both by advertisement and by demonstration, attract the attention of his clients to the virtues of the variety. In doing so he creates a demand which, as the supply is strictly limited, will enable him to charge as much as five, or even ten, times the normal rate for seed. It is this enhanced price that compensates him for his time and trouble.

We may now consider the view of the client who purchases such seed at five times the normal price. He may be a substantial land holder, cultivating his own estate, with 100 acres of wheat, for which he will require 100 maunds of seed. With wheat at 10 seers his seed wheat will have a value of Rs. 400 ; but if he proposes to sow his whole area to the new variety, he will have to pay Rs. 2000 for that seed. Let us suppose that

the improvement is represented by an increased yield of 2 maunds an acre, 18 maunds instead of 16 maunds. He will, in the first year, against an extra expenditure of Rs. 1600, secure an extra income of $4 \times 100 \times 2$, or 800 rupees. In the next year he will not have to purchase seed wheat, and his extra income in this year will be again Rs. 800, so that it has taken him two years to recover the extra expense incurred, and only after so doing will he begin to realise a profit.

Suppose, however, that, instead of purchasing seed for his entire area, he purchases only sufficient for 10 acres. His bill for seed wheat will now be $90 \times 4 + 10 \times 20 = 560$ rupees. Against the extra charge of Rs. 160 he will recover in the first year $4 \times 10 \times 2 = 80$ rupees. He will now have 180 maunds of the new variety, or more than enough to sow his whole area in the succeeding year so that, in this year, he will reap, as before, a profit of Rs. 800. He has, in fact, by reducing his preliminary purchase, realised in the two years an actual profit of Rs. 720.

The seedsman's trade is not, however, limited to the introduction of new varieties. The ordinary methods of threshing as carried out on an estate and by the cultivator invariably lead to impurities creeping in, even in the case of self-fertilised plants such as wheat; in the absence of rogueing these impurities gradually multiply up in the crop, and it is found necessary in practice to replace the seed at intervals by a fresh supply purchased from a seedsman. The purity of the seedsman's stock is usually retained in the following way. He will grow a certain area under his own supervision and control, and this crop will be rogued and harvested with rigid precautions against admixture. This seed he distributes to selected growers under terms which enable him to recover the produce and to see that the harvest is conducted under rigid conditions to avoid admixture. For this purpose he will pay the grower something more than the market price for grain at the time of harvest, and he will obtain his own financial return by selling at $1\frac{1}{2}$ to 2 times the normal price of wheat.

In the above account we have given in the simplest terms the basis for the establishment of a seedsman's business. It is dependent on a willingness to pay a considerably enhanced

price for seed required for sowing purposes. Such willingness will only be forthcoming when the cultivator has learned the value of good seed and of the desirability of purchasing only sufficient to sow a fraction of his holding. That this is so another consideration will indicate. The average yield of wheat on irrigated land is some 16 maunds per acre, and a progressive cultivator may raise his average yield to 20 maunds. For seed purposes an average rate of 1 maund per acre is a minimum allowance. This means that, under a system when every cultivator expects to purchase his entire supply of seed wheat, the producers of such seed wheat must control one-twentieth of the area under wheat. This is clearly an un practical proposition. From this consideration, too, we see that the seedsman's business can only develop when the advantage of sowing a portion of the individually owned area to selected seed and of reserving the seed of that area for subsequent sowing is generally recognised.

The advantage of the practice, even of using selected seed for sowing purposes, is as yet little appreciated in India, and we find, consequently, practically a total absence of the seedsman's trade. There is, too, another obstacle in the way of such development. The average area under individual cultivation is small, and such a seedsman would have to deal in large numbers of small parcels of seed with all the consequent extra expense of such retail disposal. Further, he would find considerable difficulty in getting effectively into touch with the individual. These form other obstacles to the establishment of the seedsman's trade. Government hitherto has carried out the function of the seedsman as here defined, and it is not necessary for Government to charge as high a price for seed as the seedsman. The seedsman has to look to a financial return on his capital and a financial recompense for his labour and skill, while there is not the same necessity in the case of Government. It is, however, as impossible for Government to undertake the function of seed producer for the entire community as it is for the seedsman. The difficulty of controlling the necessary crop area and of getting into effective touch with the individual cultivator is as great in one case as the other.

The importance of establishing a system of supply of sound seed cannot be over-estimated, and we must consider how the difficulties we have just seen to exist can be overcome. In a large measure they can be met by the development, on a co-operative basis, of Seed Supply Societies. A society of this kind is a body which has a definite status, and is, therefore, more readily approached and assisted in the matter of seed than is the individual cultivator. It is in a position to get its various members to grow portions of the selected seed, collecting the produce back for combined harvest, free from the danger of contamination, and for storage ; it is in a position, too, in a case like cotton, to arrange for isolation of the areas growing the improved selections. It can, thus, organise a system which will, by annual purchase of a small amount of seed from the Government or private seed farm, and by multiplying up this until sufficient seed to sow the entire area controlled by the members has been obtained, establish the crop in a pure condition over a wide area.

Such a society will itself be a co-operative society or closely associated with one. In many cases, where the improvement in the selected crop is one of quality, it is frequently difficult for the small cultivator to realise the enhanced price intrinsic to the better produce. The reasons will not be difficult to understand after what has been said about bulk production. As a sale society it will be in a position to place the combined produce of all its members on the open market and realise the true inherent value.

Yet another advantage is to be obtained from the system of seed distribution on a co-operative basis. It follows from what we have said on the subject of germination and storage. The ordinary cultivator is not in a position to provide satisfactory storage for his seed, even when he preserves it from his own harvest. The village money-lender, from whom the cultivator too frequently draws his supply of seed for sowing, has still less personal interest in the quality of the seed he issues because that interest is an indirect one. The society is in a position to expend capital on the erection of seed stores in which the seed can be kept without fear of deterioration.

Societies of the above type derive their justification from an assortment of benefits to any one of which it is not easy to ascribe the chief importance. We may now consider a further field for co-operation in which the advantage is better defined. In an earlier chapter it was pointed out that the accumulation of work was at a maximum at and after the rabi harvest ; that many developments of practical agriculture such as hot weather ploughing are not generally carried out by the cultivator, not because he was ignorant of the desirability, but because he lacked the power. It was also pointed out that mechanical power, if it is to be introduced, must, in the first instance, relieve the pressure on the cattle at this season. Hot weather ploughing, for instance, will not be directly performed by mechanical power, but by the cattle released from other harvest operations to the performance of which mechanical power is more adapted. Among such operations is threshing, and though experience alone will show what is the best form for the use of mechanical power, we may consider its application to threshing. Now a thresher, with what is essential in this country, a bhusa attachment and engine to drive it, is far beyond the purchasing capacity of any individual cultivator. Further, it is able to thresh out a 100 maunds of grain a day, equivalent probably to his total crop. Not only can he not afford the purchase price, but he cannot run it economically, as he cannot provide sufficient work. Both these objections are removed if a society is formed to purchase and run the thresher. If the members are unable to make full use of the plant, the society will be in a position to earn an income by threshing on contract the crops of non-members, while a judicious selection of the power plant should make it possible for the society to keep the engine in use in grinding flour, ginning cotton, and work of that nature. The time the plant is lying idle will be reduced by these means—as we have seen, a most important point in the economic handling of mechanical power.

We may, in conclusion, refer briefly to yet another type of co-operative society ; one which is in reality a co-operative sale society, but of which the procuring of the advantages of

bulk disposal is not the main feature. Certain agricultural produce, mainly dairy produce, is perishable, and unless consumed within a few hours of production will be lost. Unless, therefore, the excess in seasons of short demand is able to be converted into a less perishable article, larger decreases in price when demand is low must occur. In the case of dairying, the production of such more permanent produce, especially under conditions of cleanliness which the purchaser more and more insists on, involves a considerable expenditure on plant. A sanitary building, churns and sterilising plant, such as are essential for the handling of dairy produce, are far beyond the means of the ordinary gwala, but not beyond those of a society of gwalas. Such societies, of which the main function is to provide the capital which will purchase the plant required to bring the produce into that form in which it can be most profitably disposed, are merely a specialised form of sale society.

We have briefly in this and the last few chapters reviewed the more practical aspects of the co-operative movement. If that review has been followed the diversity of functions to which the co-operative principle can be adopted is, perhaps, the most striking feature. The reason for this is to be found in the simplicity of the fundamental principle of co-operation, namely, association for mutual advantage. Of the practical aspects the supply of credit is by far the most important, but even that importance is perhaps small compared with the educative effect derived from the mutual trust engendered and from the awakening of a knowledge that there exists something beyond the village. This less tangible asset of the movement we must leave till we are able to make a more detailed study of it.

Chapter XXXVII

THE ZEMINDAR'S ROLE IN AGRICULTURAL DEVELOPMENT

We have now considered in some detail the cultivator and his position in relation to agricultural development, and, if we have understood arightly, we will draw the conclusion that all the developments we have discussed lead to the emancipation of the cultivator, to rendering him a free individual. We must not forget, however, that the cultivator is not the only person who has to be considered. There are, as we have seen, two further main interests in the land which must be considered, those of the land-holder or zemindar and those of the Government. The demand for agricultural development is, fundamentally, twofold, the increase of the amount of produce obtained from the land to meet the needs of the expanding population and by raising the balance available for export, addition to the wealth of the country. It does not merely aim at increasing the wealth of one section of the community at the expense of the others, and we must now view the development we have so far discussed from the point of view of the zemindar and Government, both as to the methods in which they can aid in the development and also as to the share they will receive from the additional wealth which accrues. We have also to consider the position of the village money-lender whose business will be undermined by any large development of the co-operative movement. We may consider the position of the zemindar first.

The small zemindar who cultivates all, or a large part of his holding, is well represented in the United Provinces, but his

position is, from the economic aspect, more nearly approaching to that of the cultivator we have referred to above. He is eligible for membership of the co-operative societies, and his future share in agricultural development is best obtained through that source. It is for this reason that we have throughout recent chapters referred to the cultivator rather than to the tenant. We are now concerned with the larger zemindar, who may possess a certain amount of khud kasht, but whose major, if not entire, income from land is derived from his rental. In discussing the present agricultural position we saw that competition for the land was so great that the land-holder was in a position to force up rents until the entire profits to be derived from any development were entirely absorbed by rent. As long as that condition holds, the developments we have indicated as possible as the result of the provision of capital through the co-operative movement must remain largely inoperative, for a tenant will not borrow, even on the relatively easy terms offered by the society if he knows that the bigger return which he obtains by doing so will merely lead to an enhancement of rent equivalent to the extra value of his produce. Nor can we blame him for making no effort, and it is equally difficult to blame the land-holders for taking advantage of the economic position in which he finds himself. This is such that he is able to enhance his income from year to year with small effort to himself; the enhancement is readily recognised, and it requires a large amount of courage to forego an obvious, definite and immediate enhancement for a less obvious and distant, though probably greater, profit.

Nevertheless, the enhancement under the former system has no material increase of wealth to justify it; it merely consists of a redistribution of the normal wealth in a manner which is undoubtedly inequitable. Under the latter system profits are derived from a sound increment in the wealth produced, and it will only be when landholders as a body come to appreciate this fact that full advantage can be taken of the field for agricultural development.

This, then, is the first essential point that we must recognise in considering the position of the zemindar relative to agricul-

tural development. It is to his interest to refrain from forcing up rents ; to recognise that if the return from the land is to be increased, that return will be due to the tenants' extra labour, and that labour will not be given if he is to retain no part of the fruits of his labour. He must learn that he will only be able to judge correctly of the progress of his estates in this direction by personal supervision and by personal inspection. He must appreciate the danger of working through karindas who are necessarily judged by their returns, and who are practically forced by the circumstances of their position to pay more attention to the present returns from, than to the future development of, the property. This implies recognition by the zemindar class of a large field of personal work on their estates.

We may consider the zemindar's position under the same main heads as we have adopted in the case of the cultivator: knowledge, capital, and handling in bulk the outcome of transport facilities. The first of these lies outside the scope of this book. We have already indicated the type of knowledge that is required to lead to success, and we will only add that the relative wealth of the class we are now considering removes the necessity of labour during youth, and consequently affords opportunity for education and the acquisition of that knowledge. Capital this class possesses in greater or less degree ; and if associated with knowledge, the field for its employment is large. This field is twofold, and covers the development of the property and the disposal of agricultural produce. Many of the improvements we have suggested as being brought within the scope of practical development through the agency of the co-operative society, and, in fact, the particular instance we selected to illustrate our meaning, that of a well, form a suitable field for the employment of capital by the zemindar. Let us take the instance of a well that we have considered before. Clearly, this is not a desirable object for which the tenant at will would borrow from his society, for he is liable to be evicted even before the well could be completed. Even the morusi tenant and small zemindar, owing to the generally scattered nature of the holdings, are in

many cases not in a position to derive that benefit from a well which would make it economically desirable to sink it. In such cases it is a legitimate investment of the zemindar's capital to sink a well, the return on the expenditure being derived from an enhanced rent over the area covered, by a fee on actual water supplied or by a charge for the right to use the well, the method depending on whether the cultivator lifts his own water or whether this is done by the zemindar with machinery supplied by himself. The essential point, and the point which is so frequently overlooked, although it is so vital, is that, before the work is put in hand, a complete and detailed estimate of the cost and risk involved should be drawn up, and the financial aspect of the scheme thoroughly scrutinised. We are not proposing that the zemindar should pose as a philanthropist. We are proposing that he invests his capital in his own property as a business proposition, and we must show that, by so doing, he will earn a legitimate interest on the capital so invested. Unless he knows the cost he will be unable to determine the extra rental or the charge for water for which there will be a definite maximum determined by that portion of the enhanced value of the extra produce which may be legitimately claimed for the water facilities provided by the well. If more than that portion has to be claimed to pay the legitimate interest on the capital cost the undertaking is financially unsound.

We will not here multiply instances of the profitable use of capital in the direct development of the estate. We have attempted to show that these are great, but, still more important, we have attempted to indicate the way in which the zemindar should approach them if he is not to run the risk of having to choose between rack-renting his tenants and gaining a poor return on the sum invested. Great as these opportunities are, our study shows us that agricultural progress depends still more on the cultivator who directly tills the soil. As we have seen, the main need of this class is for small loans which can be provided by the co-operative societies. It is too frequently the case that those loans go to meet the landlord or his karindas' demand for rent. They would be unnecessary if the rental were not the rigid item it usually is. The landlord

might himself make the loan to the tenant or, in other words, remit payment for a time. Again, we are not concerned with the zemindar as a philanthropist, but as a business man, and we must search for the return which forms the legitimate interest on the capital which represents the rents held over for subsequent payment. He may, of course, charge an interest on the sum held over, but the main return will not be here. It will be found mainly in that much more intangible asset, his reputation as a good and lenient landlord. That reputation will attract the tenantry and will allow him to select as his tenants those who are the most enterprising.

He may even go further than this and advance capital to his tenantry, thus taking the place and doing work of the society. Such a position is not without its disadvantages; it implies a dependence on the part of his tenantry, which is only justified by his personal character, and a time will come when his successor will obtain possession. Unless his successor possesses the same character the position of dependence in which the tenantry are now placed will encourage and render easy oppression. The zemindar will, therefore, be well advised to leave such loans to co-operative societies, to encourage the development of such and, if he wishes to employ his capital for such purposes, to lend it to the central society—to lend it directly to a primary society of his own tenants, would remove that spirit of independence which is the essential feature of the co-operative movement.

The zemindar will find further employment for capital in the disposal of the produce raised by his tenantry. We have discussed at an earlier period the system of payment of rental in kind, and we have seen that, though simple and equitable in theory, it leaves openings for much abuse. We have seen further that mechanical power, if it is to obtain a use in agricultural practice, will probably develop in a form which will enable threshing of the rabi to be so accomplished. We have suggested as a field for co-operative action the purchase of a power thresher to liberate the cultivator's cattle for other forms of work. In this direction the zemindar might reasonably find a field for the employment of capital, perhaps combining there-

with a realisation of rent in kind. By such means he would place himself in a position to reap the advantage of bulk disposal. In any such development, however, the same considerations of both reasonable interest on capital and of a residual share to the tenant must not be lost to view.

To any of us who are accustomed to travel much about the districts, the distance at which many villages lie from the nearest rail or pukka road and the condition of the connecting kuchha roads are well known. Frequently these are such that traffic is interrupted for months at a time. This means isolation from the markets, and, consequently, lack of freedom in the disposal of produce. But even if actual interruption of traffic does not occur, the additional cost of transport along a kuchha road is considerable, and at least twice the cost when the road is pukka. A bullock cart, for instance, will take a load of 30 maunds 25 miles in one day at a cost of about 14 annas. If the road be kuchha, the load will have to be halved, or the time taken doubled. With larger loads and suitable distances the actual increase may be somewhat reduced, but against that reduction must be placed loss of time and wear and tear, so that the estimate of double cost will not as a rule be excessive. A consideration of the goods available for traffic will now permit the calculation of the saving due to the conversion of a kuchha, into a pukka, road, and it should be sufficient to pay a considerable portion of the interest on capital cost and of the cost of maintenance of the pukka road. We have said a considerable portion only, because the freedom in disposal which the pukka road offers, difficult though it is to ascribe an exact figure, must be considered in any calculation of the return obtained.

The whole question of opening up the country by means of pukka roads is worthy of study. We are considering it as within the field of activity of the zemindar, but, except in so far as it is possible to put his homestead into communication with the public roads, it hardly lies within his province to undertake road building. It is, however, to his interest, perhaps more than to the interest of any other class, to see that pukka roads are maintained; and he has the influence, if he cares to assert it, to direct the attention of the District Boards to this work.

We have attempted to indicate, though necessarily in a very cursory manner, the direction in which the zemindar can assist in the development of agriculture. Stated in general terms, this direction is in the employment of his capital for the development of his estate. Of such employment the examples we have given form only a few of the numerous ways, and by no means exhaust the list. We shall have missed the main object of our discussion, however, if we fail to note a common feature of all these proposals which is the implied intimate relation of the zemindar and his tenantry, the recognition by the zemindar of the justice of the tenant's claim to a fair share of the increased profit and his allowance for such a share in his calculation as to the financial aspect of the employment of capital in estate development.

Chapter XXXVIII

GOVERNMENT'S ROLE IN AGRICULTURAL DEVELOPMENT

We have now to consider the third interest in agricultural development, namely, Government. Government, as we have seen earlier in these chapters, serves a twofold function; it is responsible for the external defence and for the internal administration of the country. As part of the latter responsibility it should do all within its power to increase the material wealth of the country which, in a country like India, where agriculture forms the predominant industry, implies the encouragement of agricultural development. Action with this object may be direct, that is, the direct undertaking of works aimed at development of the agricultural wealth of the country; or indirect, that is, guidance of the economic conditions under which agriculture is developed into lines which will render that development easy. We may consider these two processes independently.

We have seen that the cultivator is a man of small means with a very limited sphere of activity. He can do much to improve the average outturn of his fields if he be provided with the necessary capital, while, by means of co-operation, his personal influence can extend beyond the limits of his own fields. But at best his efforts are purely local, and he cannot undertake any scheme which requires either considerable capital or will affect any large area. The landholder or the zemindar is a man of larger resource, whose influence extends over a considerable area. He is in a position to develop schemes of considerable magnitude and to exert his influence in the direction of progress throughout that area. But even so his sphere is limited, and he is not in a position to initiate larger

schemes which affect the area outside his own estate. It is in such cases that a profitable field for governmental direct action arises.

Perhaps the clearest example of such action on the part of Government lies in the canals of Northern India. These are of such magnitude that no single zemindar could find the capital, nor, in the case of the main canals, has any single zemindar control over the area which one of these commands. Schemes of such magnitude can only be undertaken by an agency which has power to take up the land required for the purpose, and which can command the necessary capital, and that agency is Government. In such cases Government has to consider the financial aspect of the scheme, and, in the majority of cases, that return must pay a reasonable interest on the capital cost to justify the undertaking. This is true of all the large canals arising from the Ganges, the Jamna and the rivers of the Punjab. But in special cases, as in some of the Bandelkhand canals, where the local conditions render the cost of construction heavy, the direct financial return may be too small to pay interest on the capital. Such canals are definitely protective, and their construction is justified by the indirect return, that is, by the protection they afford to the area commanded. They are constructed in tracts of precarious rainfall which, without such protection, would be either depopulated or support a meagre or destitute population.

Lines of communication both road and rail form another opening for direct Government action. We need not here lay stress on the importance of these since we have repeatedly laid stress on the economic effect of cheap means of transport on agricultural development. Clearly also the course such lines follow is not a local problem if they are to form a connected series working as an economic whole. Government alone possesses the means of co-ordinating the various efforts, and must, therefore, take the initiative in their development. Whether it delegates its power to other bodies is of secondary importance. In the case of railways it is commonly the case that the actual construction and financial burden is taken by a company, but, for the right to acquire land and for the decision

as to route, the company has to look to Government, which determines these points only after consideration of the function it is to fulfil, into which consideration in an agricultural country the outlet offered to agricultural produce of necessity largely enters.

In the case of roads a similar necessity for Government action in co-ordination and acquisition exists. The capital cost is, however, relatively small and the use comparatively local. Construction and maintenance is, therefore, largely a matter for control by local bodies such as District Boards which will be guided in their policy of construction of all except the main roads of the country by considerations of facilitating the traffic in agricultural produce in its passage to the railways. Such a system of feeder roads as we may term them is as yet in its infancy, and there is ample scope for a large and economic development of these.

The indirect Government action is manifold, and is aimed at bringing about those economic conditions which will render possible the largest development of agricultural wealth. In its broadest aspect every action of Government tends in this direction. We have, for instance, referred on more than one occasion to the necessity of knowledge if the agricultural population is to benefit to the full from the labour of its hands. Indirectly, therefore, the educational policy of Government has a bearing on our discussion. It is not possible, however, to discuss such subjects, and we will limit our review to a few of the aspects of more direct concern to agriculture.

Every Government requires money to carry out its functions, and those funds are raised by taxation. In India it has been customary to look to the land to provide a large portion of these funds. The position of Government as a partner in the land has already been explained, and the land revenue, or malguzari, represents the Governmental share as part owner. The position is in principle quite clear, but in practice the equitable adjustment of the incidence of that charge is far from simple. In principle Government should share in the profits arising from development, and should equally share in any loss due to bad seasons. Such a flexible assessment is practically impossible,

and, in practice, a periodical settlement is undertaken at which necessary adjustments are made, seasonal adjustments being made when necessary by remissions and holding over collections. The fundamental consideration in such periodic settlements should be that at a minimum, a sufficient revenue be left to the zemindar to make it worth his while to invest capital in the development of his estate, and, at the same time, to share the proceeds of the development with his tenantry. Unless this is effected the assessment will be placed too high.

We cannot do more here than glance at the essential features of the policy adopted during a short period early in the last century which led to the permanent settlement in Bengal. That policy was based on the economic theory that, by leaving the zemindar a free agent, having sole rights in any improvements effected in his estate, a class of progressive landholders would be built up. Experience has shown the fallacy of that argument. The effect has been directly opposed to that anticipated. Land has, owing to its appreciation, become an item for investment by a non-resident and non-agricultural body, who merely look on it as a source of revenue. High rentals and poor practice, characteristic of a depressed cultivating class which works only to obtain the necessaries of life, knowing that any production above that will pass to others, is the result. The conditions are the antithesis of those we have seen to favour agricultural progress.

Intimately connected with the land revenue system is the famine policy of Government. This has been shown to be due, not to the absence of food, but to the absence of the wherewithal to buy the food that is available. That leads to one aspect of famine policy, the provision of work at which those affected will be enabled to earn the money necessary to buy the food available. But that is one aspect only. Owing to the periodic assessment of land revenue, a figure which is perfectly equitable as an average over the 30 years of settlement, may, and probably will, prove too large in a famine year. To realise it in full will mean the deprivation of the cultivator of his cattle and his implements, of all, in fact, which will make the cultivator a wealth producer on the return of favourable conditions. Next

to maintaining the cultivator on the land the essential necessity is to maintain him as an effective producer. Remission of revenue to prevent the disposal of his means of cultivation and even takkavi advances to replace what he has been forced to sell, are more than justified in the result. Their true bearing as incidental to the revenue system must be appreciated if their function and the legitimate field for their employment is to be understood.

If Government at settlement bases its calculation of the revenue on the arguments we have just considered, it is also its function to see that the other partners to the agricultural wealth make a like equitable distribution of the remainder after the land revenue has been met. What form the relation of the tenant to the zemindar takes we have already had opportunity of discussing. From a time when the zemindar had difficulty in attracting a sufficiently large tenantry to cultivate his estates, the increase of the population has developed a condition in which the cultivators compete for the available land. It is a condition which the progressive zemindar can use to the full, for it permits him, by the offer of fair and equitable terms, to attract a progressive tenantry. But it also affords the grasping zemindar an opportunity to force up his rents to a figure which leaves the actual cultivator the minimum necessary for existence, a condition inimical to progress. The only real remedy is to convince the zemindar that such action does not pay in the long run, but that is an educative process, and slow; slower, probably, than the development of the evil. A more active policy is required on the part of Government, and such a policy is developed in the recent land acts. Complicated as these are we can see running through each, and underlying the adaptation of each to the laws which govern the distribution of land in each tract, a definite effort to attain an equitable distribution of the residual profit between zemindar and tenant. If we have grasped the position arightly we will understand that such Government action, necessary though it may be, can be only palliative, the true remedy lying elsewhere ; and it is only such understanding which will prevent the remedy, as expressed by the act, proving worse than the disease. Such a

condition would arise if the act, effective though it might be in checking the evil, prevented the gradual development of that co-partnership which we have seen to be the true line of economic progress.

There remains still another field for Governmental intervention in agricultural development. Our consideration of the foundations of practical agriculture have shown us that all agricultural practice is based on cause and effect in the first instance as determined by observation, and later as a matter of interpretation. Study aimed at determining the cause will suggest lines for directed improvement, which trial may prove to be advantageous. Such study, in its widest aspect, forms the basis of agricultural research, which, in common with all research, requires trained investigators and a considerable expenditure. The returns in the long run are sure, but, in any particular case, uncertain, and it is, therefore, not within the power of the individual to carry on investigations of this nature. For this purpose Government is in a position to supply funds without the necessity of considering the financial aspect too minutely. Such investigation, to which must be added the equally important business of introducing any practical developments into general use, is the rôle of the Agricultural Department, the return for the expenditure on which must be sought in the greater prosperity of the country side. How intimately this rôle of the Agricultural Departments is associated with the other fields of Government activity one consideration will be sufficient to show. To influence the general agricultural practice it is necessary to convince the cultivator that the policy is to his advantage, and it is clearly easier to convince such an one if he be intelligent. The problem of agricultural development is, thus, intimately bound up with the problem of rural education. We shall have failed in our object if we have not succeeded in making it clear that agricultural development is not an isolated problem, but one which has to be considered in relation to the development of the community as a whole. Progress in agriculture only is not possible; it must be accompanied by a concurrent progress in other directions also if it is to be firmly rooted.

CHAPTER XXXIX

THE MONEY-LENDER'S ROLE IN AGRICULTURAL DEVELOPMENT

WE have referred to Governmental action towards agricultural development as being either direct or indirect, and we have considered a few cases in illustration of such action. In all these cases the action is what we may term positive, or active. The building of canals, roads and rails are clearly of this nature ; the efforts of the agricultural departments are, perhaps, less clearly so, while the active character of the collection of revenue is too obvious to require comment ; but Governmental action should be in the direction of making that activity as little irksome as possible. There remains a distinct field of Government activity to which we may apply the name negative. The characteristic feature of such action is implied by that word. The initiative in such cases must arise within the population itself, and Government action can only take that negative form which fosters such initiative. We may consider a few examples which fall in this category.

We have devoted a good deal of time to an exposition of the basis of co-operation, and we will have failed in our object if we have not made it clear that the movement is essentially of the people for the people. Government could, no doubt, take action which would facilitate the rapid development of the movement, the rapid multiplication of societies and the rapid increase of membership. But such action would stultify the very movement which aims at inculcating self-help and self-reliance. The most Government can do is to foster conditions which are favourable for co-operative development. Any further action is likely to be harmful to the movement. As instances of such legitimate action we may refer to the passage

of the Co-operative Societies Acts which recognised the legality of such societies when registered and rendered the comparatively costly registration under the Company's Act unnecessary. We may also refer to the audit imposed on societies registered under the act ; an independent audit which, while refraining from interference in the management, created a sense of security which is so necessary when the rate of interest on the loans required is the matter at stake.

In considering the incidence of the land tax we had occasion to note the danger incurred by Government in any effort at relieving the position of the tenant from the effects of land competition due to increase in the population. The recognition of morusi rights under the Tenancy Act of 1901 illustrates this danger well. While confirming occupancy rights on all tenants of long standing at the time, it clearly compels the zemindar to refuse to his tenants at will any lease which will be the equivalent to confirming on these such rights. That danger happily was recognised and due provision made ; had it not been recognised, the position of the zemindar who was desirous of attracting to himself a progressive and contented tenantry would have been unfortunate, for fixity of tenure is fundamental to progressive agriculture. No cultivator will put energy and skill into appreciating his holding if his tenure be such that he may be deprived of reaping, with no compensation, the reward of that labour ; and to have compelled the zemindar to keep his tenantry in the position of tenants at will would have been to handicap that one who had the real interests of himself and tenant at heart.

The remedy which the acts passed by Government from time to time apply are, in truth, as we have said, merely palliative ; to ascertain the real remedy we must discover the root of the evil. That root lies in the rate of increase of the population acting in association with the tenacity, found in all truly agricultural populations, with which the cultivator clings to land. These two facts in the case of the tenantry lead to, besides increased rentals, the steady reduction in the size of the holding until the area becomes insufficient to support the needs of the occupant. In the case of the zemindar there is a third

factor which comes into force, and that is the laws of inheritance. Both Hindu and Mohammedan law recognise equality of right between the children, and from this arises the joint family system. As long as that division is limited to the produce of the soil the disadvantage of the system is not strongly marked, but a time comes sooner or later when a dispute arises and leads to a demand for division of the land, a division which may be applied to each field of the holding. Not only, therefore, may the holding be reduced to a fraction of what must be considered the economic minimum, that is, the amount which will support the owner and his family, but that holding may be composed of several microscopic fields scattered throughout the village cultivated area.

It is hardly possible to conceive a more ineffective system, or one the adoption of which would render impovred methods of agricultural practice more difficult. It is a condition for which a remedy has to be found, and for which a remedy must be found if agriculture is to develop and to form a foundation for the economic strength of the country. That remedy must be sought and will be found only in the clear appreciation of the causes which have brought that condition about.

That fundamental cause is found in the increase of the population, a factor which no Government can influence. But while Government is neither willing nor able to influence the rate of increase in the direction of its reduction, it is able to influence the distribution. We have referred to the tenacity, born of affection, which the cultivator exhibits towards the land, and especially towards the land of his home. That is no doubt an obstacle to separation between the agricultural population and the land, but it is not an insuperable one. Such a separation implies, however, deprivation of income to that portion of the population which migrates, and, if that migration is to take place, the provision of a secondary means of earning a livelihood becomes essential. Such a means is provided by industries, and in the promotion of industrial development Government has the readiest means of relieving agricultural congestion. The method is essentially of the type we have termed negative. Government can do nothing in the direction

of direct distribution of the population; it can merely afford to guide and foster such migration as arises automatically.

We have also referred to the restrictive influence which the laws of inheritance exert upon the economic and practical development of agriculture. In so far as the provision of an alternative means of livelihood will relieve the situation by providing a field of activity for those of the joint family who prefer to go abroad, the industrial development we have referred to acts as a palliative. The interest in the land, however, remains, and the member of the family left to cultivate is not a free agent; at any time a co-sharer may return and demand the separation of his portion. The remedy for this lies with the people themselves, and not with Government, which can only foster such tendency as may arise from within for members of the joint family to leave the land. Governmental action of this nature is again negative, and the fostering of industries again affords the surest remedy in so far as it develops the necessary alternative livelihood.

While a positive policy is not possible in districts which are already fully settled there remain still many tracts far from densely populated. We shall be in a better position to realise the real relation of Government to this and similar questions, and to appreciate the extent to which policy is dictated by the economic conditions prevalent if we turn to tracts in process of settlement. The Punjab Canal Colonies form such a tract in which the indigenous population, if it existed at all, was numerically totally inadequate to till the large tracts laid open to cultivation by the construction of the canal systems. An adequate agricultural population has here to be created, and Government is in a position to insert in the terms under which it makes grants of land to colonists conditions which limit the degree of sub-division permissible.

This action, as in the previous case, is preventive, and is aimed at eliminating the over-divided property by denying facilities for its development. In the tract already fully settled uneconomic sub-division has already proceeded a long way. Preventive measures are here inadequate, they may serve to check the extension of the evil, but they cannot

remedy the harm already done, and further action is required if a cure is contemplated. We are here face to face with what is at once one of the most serious checks on agricultural development, and one of the economic problems most difficult of practical solution. We have to discover a means of raising the unit of cultivation. The problem is, in reality, twofold. As we have seen, the unit holding is not only small, it is subdivided and scattered. Even without raising the size of the unit holding, therefore, much could be done by a redistribution of the land to bring the scattered elements together to form a compact block. There are many practical difficulties to such a proposal which will occur at once to anyone who has experience of the countryside. From the aspect of practical agriculture, there is the quality of soil and the distance from the village to be considered; while, on the economic side, there is the cost of registering the title deeds which the redistribution would entail. In such matters Government can do little, forcible interference in the direction of aggregating holdings, with the alienation of a portion of the population which such action would involve, is unthinkable; even were it not so, the agrarian disturbances which other countries have experienced as the result of forcible intervention with the people's rights in the land offer sufficient warning. Government action in what has come to be known as restricting and in consolidation of holdings can only be negative in the direction of facilitating any spontaneous movement in that direction. That action would include, for example, facilities such as reduction, or remission, of legal fees for the registration of rights where the change to be recorded involves either the raising of the area held to a certain minimum or the collection into compact blocks by exchange of previously scattered fields. Further action can only be as the result of spontaneous demand from the land-holding class, and that demand will not arise until the evils of the present system have been brought home to the understanding of those practically concerned. This education alone can effect.

We have now summarised the lines of agricultural development and studied the relation of the cultivator, the landowner and the Government towards that development.

We have still to consider the position of that essential member of the village community, the money-lender. If the development we have outlined in any way represents that which will actually take place, it follows that the position of the money-lender as such will be undermined. Cheaper credit will be obtained through the co-operative societies, and the need for loans will consequently diminish. At first sight, therefore, it would appear that the village money-lender will not share in the general benefit arising from the development we have outlined, and it must be admitted that this is the view taken by many of the profession. Were it the fact it would be impossible to delay development which reacts for the general good, because it is harmful to a small minority. No progress is possible without a certain amount of readjustment, and in the history of every such step is written the opposition of the injured minority. In the present instance, however, the opposition of the money-lending class is not justified by facts. The rates of interest paid on capital will no doubt be reduced, but that reduction represents not a reduction on the nett, or legitimate interest, but the equivalent of the diminished risk· The co-operative central bank offers a legitimate field for investment at rates which are legitimate in proportion to the risks run, and to reject this field for investment implies a familiarity with rates which are higher than the risk justifies, and, therefore, bordering on usury. With hostility based on such grounds there can be no sympathy.

While claiming for the co-operative movement that it provides an opening for legitimate investment with a return which should justify legitimate demands, we must admit that it is one that fails to appeal to the instinct which compels a large proportion of the human race to take a measure of that risk which is termed gambling, and it would not be surprising if the safety conferred by investment in the co-operative bank failed to make up for the loss of the means of satisfying that instinct. We must, therefore, look further for the opening which will satisfy this need if the natural opposition of the money-lender is to be overcome. Any improvement in the conditions of existence of the cultivator and his materia

welfare will be accompanied by an increased spending power, will add, that is, to the demand for articles not locally produced.

We must all have noticed the manner in which the use of shoes and even umbrellas has recently developed in the mill population; and the way in which a demand for articles which would, a short time before, have been termed luxuries, arises as the result of increased income is well illustrated by this example. Even if a demand for such articles is less likely to arise in the district, the consumption of such articles as cloth will increase. Such increased consumption, whatever the article consumed, involves a trade which the village money-lender is well qualified to perform, and one which he even now performs in its present limited development. In such trade there is ample scope for satisfying any legitimate desire for speculation.

CHAPTER XL

THE ECONOMIC ASPECT OF CATTLE

WE have dealt briefly with the question of cattle as a source of power, and, in discussing that aspect, were led to the conclusion that this question was, to a large extent, an economic one. We must now consider this economic aspect more fully, for it is not too much to say that, if the provision of cheap capital to the cultivator is a matter of primary importance in agricultural development at the present time, the provision of efficient cattle is hardly of less importance.

A bullock is an organism, and, as we have had occasion to remark before, requires a regular and sufficient supply of food if it is to maintain that condition of health which will alone permit it to develop its full capacity for work. Especially is this the case with young stock when any too long exposure to adverse conditions will result in constitutional weakness which may persist through life. What, now, are the ordinary conditions under which the village cattle live? During the rains there is an abundance of green fodder, both in the natural growth of uncultivated areas and in such crops as chari grown to supply fodder. With the cessation of the rains and the coming of the cold weather natural growth ceases and the fodder crops ripen off. Fodder is now limited to the dry stalks of jowar and maize and to the bhusa produced from the cold weather cereals, to which must be added the withered grasses of the waste lands. Grains and pulses are little used as cattle food, nor is the use of cotton seed, even in the form of cake, appreciably adopted. On these fodders, having small nutrient value, eked out with such little natural grazing as is available, the cattle have to struggle along till the succeeding rains brings forth a new supply. Moreover, within this period falls, as we have seen, the season of maximum demand for power for agricultural purposes.

How insufficient is this food supply, even in a normal year, will be apparent to any of us who have seen the herds of cattle roaming in the hot weather over the bare fields and dried up wastes and picking up a bare subsistence in their progress. It is apparent to any of us who have taken the trouble to note the condition of the animals at that season of the year. And if such is the condition of the cattle during a normal year, their lot is still more deplorable during a year of famine. We have considered at some length the effect of famine on the human population. At the present time storage of grain and the capacity to import from other parts of India, and even from other countries, has now removed any danger of want on the grounds of actual shortage of food. In the case of cattle these safeguards do not exist. No sufficient excess of fodder is produced in good years, and its bulky nature prevents the importation of appreciable supplies even were external sources available. Famine, therefore, in the case of cattle, reproduces the conditions we saw to exist in Bengal in the case of human beings when the means of transport did not exist. The beasts die by their hundreds, and those that survive are rendered inefficient as workers for some time to come. Nor is the effect temporary. As has been said, young stock require particular care, and such stock as survives is permanently weakened.

Such a reduction of numbers in the stock of working cattle, and such a diminution in the working capacity of those that survive, can only react to the detriment of the country as a whole. Before agricultural operations can be fully undertaken with the return of the rains, certain cultivators, who have lost their working stock, will have to contract loans to replace them while others will be dependent on cattle no longer capable of developing their full power or rendering a full day's work. Under such conditions the land cannot be efficiently ploughed, and a reduced outturn must result.

It will help us in studying the economic aspect of the question of cattle as a source of agricultural power if we refer again to what has been said with reference to the fundamental causes at work. At no very distant date the population of the United Provinces was relatively light and scattered, though

the density of this population was greater in the East of the Province where the conditions of climate are less severe. Such a scattered distribution allowed of large expanses of waste land forming a natural reserve in which the comparatively few head of cattle could pick up a fair means of subsistence. With the pressure of population, brought about by more settled conditions, the cultivated area increased and a simultaneous increase in the number of head of cattle took place to meet the demand for additional power required to cultivate that additional area. This increase has been accompanied by a corresponding diminution in the available waste, combined with stricter forest rules with regard to grazing, with the result that the present natural grazing cannot provide the requirements of the large number of cattle now employed. The result, as we have already seen, is a yearly recurrence, more or less intense, according to the nature of the season, of a period of fodder shortage when the cattle suffer from famine. It is difficult to obtain any clear idea of the intensity of this struggle against adverse grazing conditions. We may, however, gain some idea by a comparison with English conditions. In England, 15 acres of grass land will support 10 head of cattle. Half of this area will be in hay to provide fodder for the winter; the other half will be grazed. We may say, therefore, that three acres of grazing will support four head of cattle. We must remember, too, that these figures refer to the rich pastures during the season of growth; they are in no way comparable to the parched tracts commonly referred to when the grazing grounds of India are under consideration. In the United Provinces, excluding the hills, there are some 300 lakhs head of cattle, while the uncultivated lands amount to less than 200 lakhs of acres. This gives only two-thirds of an acre grazing land for each head of cattle, an area less than that allowed in the case of the pastures producing many times the weight of fodder yielded by the waste lands used for grazing in the United Provinces.

The problem is a difficult one, but its solution is of vital importance for the full agricultural progress of the country. Clearly. it is not possible to revert to the conditions which

formerly existed and increase the waste lands available for grazing. Such an increase is only to be obtained by the relinquishment of land already brought under the plough, while the economic pressure due to increasing population is directed to a still further diminution in the area of uncultivated land. We have, therefore, to search for a solution in another direction.

That any ready solution will be found is not possible, for economic forces work slowly. Nevertheless, the direction in which development will take place can be safely indicated. The problem is no new one. It has arisen in all countries in which the pressure on the land has led to partial or complete absorption of grazing grounds. It has been met in England where, however, the capacity for importing foodstuffs at a lower rate than these can be produced in the country, combined with the higher money value of live stock, has rendered it sound economically to lay down good agricultural land to pasture. It exists in full force in Egypt, where the population is exceedingly dense and grazing land practically non-existent. In the latter country, in which the uses to which cattle are put more nearly approximate to those of India, these are stall-fed, and the necessary fodder is grown as a rotation with maize, cotton, wheat, barley and other crops. This purely fodder crop is supplemented by the bhusa from cereals and by the stalks of, as well as by green, maize, which is a crop widely grown.

We can only conclude that stall-feeding is a custom which must develop in India as it has elsewhere, if full power is to be obtained from the cattle raised. But here again we are met with an economic difficulty. Stall-feeding implies the cultivation of fodder crops, and these will only be grown when the economic value of maintaining a robust stock is fully appreciated. It depends, further, on the existence of a suitable crop which it will pay better to grow than the crops now commonly cultivated. We must remember that the return from a crop, such as wheat or cotton, is direct and easily appreciated, while the return from a fodder crop is indirect and less readily recognised. We cannot conceive of a large increase in the area under jowar, for instance, at the expense of other crops.

Jowar yields a produce at the time when fodder is plentiful; the value is regulated by the demand, and only the assurance of an obvious and relatively high price would stimulate the sowing of a larger area. The increase of the fodder supply is not to be sought in this direction.

If we look at the question broadly, we must conclude that the fodder crop which will pay best is that which will give a return at a time when the supplies are at their lowest. This period is during the hot weather, and until the rains bring on natural vegetation and the new rains crop. This is a season of intense drought during which no crop will grow without water. The water supply is thus the limiting factor; and, where water is available, as in the irrigated tracts of some of the western districts, the growth of lucerne is frequently, though by no means commonly, undertaken. In the eastern districts the solution of the problem is not so readily indicated. Owing to the smallness of the individual holding, even a small area of fodder makes an appreciable difference to the land available for the production of the crops required to produce the essential needs of the cultivator who can, therefore, ill afford to set aside even a small portion of his holding for fodder crops. We are here faced with economic forces of another nature, under the influence of which even water in sufficient supply would not, in all probability, lead to the adoption of stall-feeding. In large tracts of the Province, however, the problem of cattle is closely dependent on the problem of water supply, and the solution of the former will only be achieved when the latter problem has been solved. We have referred to the manner in which the cattle problem in Egypt has been solved. That solution was rendered possible by the wonderful irrigation system there developed, which provided an ample supply of water throughout the year.

Nor does the cattle problem end here. We have at an earlier stage dealt with the need for improved stock, and of the desirability for breeding for the type most suited for the work required. Breeding, however, can do very little to raise the power capacity of the stock of the country as long as the conditions under which the stock has to live remain adverse.

Large as is the field for breeding in relation to stock, the fodder supply remains the essential factor of the situation.

We have considered the question of stock in some detail, not only on account of its intrinsic importance, but also because it illustrates well a fact we have tried to emphasise, namely, that the problem of agricultural development is not a simple one. Each practice will be found to form an integral part of the general practice, so intimately connected with the remainder that no alteration in the one can be effected without far-reaching effects on the remainder. We have seen that the practice of hot weather ploughing has failed to be generally adopted, although the cultivator is, in all probability, fully alive to its advantages. It is lack of ability to find adequate power, rather than any objection to the work involved, that deters him from such adoption. That inability is now seen to depend on the further inability to provide the fodder crops required to maintain his cattle in full vigour ; an inability due, in some cases at any rate, to inadequate water supply, and, in others, to the intensive sub-division of the holdings brought about by increased population. If we have learned our lesson aright we will recognise the close interdependence of the practical and economic aspects of agricultural development ; a lesson it has been one of the main objects of this book to inculcate.

GLOSSARY

ANNA.	16 annas equal one rupee ; one anna roughly equals a penny.
ARHAR.	Cajanus indicus, Spreng. ; the pigeon pea.
BAINSURAI.	Pluchea lanceolata, Oliver and Hiem.
BAJRA.	Pennisetum typhoideum, Rich.
BAZAAR.	Any market or collection of shops.
BHUSA.	Straw in the broken condition after the grain has been trodden out by cattle.
BUJA.	Any rick such as a hay rick.
CHARI.	Andropogon sorghum, Brot. when grown for fodder.
CHOWKIDARI.	The business of guarding ; from chowkidar, a watchman.
DOFASLI.	Adj., from fasl, a crop season ; a dofasli system is one in which two crops are grown on the same land in one year.
EKFASLI.	cf. dofasli , one crop only is produced in the year under an ekfasli system.
GWALA.	A cowherd.
JHAO.	Tamarix gallica, Linn.
JHEEL.	A swamp.
JOWAR.	Andropogon sorghum, Brot.
KADIR.	The low-lying land of a river bed subject to inundation.
KANKAR.	Nodules of limestone found in the alluvial deposits of the Ganges valley , in cases they may coalesce to form a practically continuous stratum.
KANS.	Saccharum spontaneum, Linn.
KAPAS.	Seed cotton.
KARINDA.	An agent.
KHARIF.	As applied to crops refers to a crop grown during the rainy season.
KHUD KASHT.	Cultivation by owner.
KHURPA.	A hand hoe.
KUCHHA.	Crude ; when applied to roads=unmetalled, e.g. a cart track.

LOHAR.	A worker in iron.
LOTAH.	A brass domestic utensil, chiefly used for holding drinking water.
MAIDAN.	A plain, open country.
MAKKAI.	Zea mais, Linn.
MALGUZARI.	The tax on land.
MAUND.	A variable measure, the standard maund=approx. 82 lbs.
MORUSI.	Adj. hereditary. A morusi, or occupancy, tenant is one who retains a permanent lien on his land.
PALEWAT. PALEO.	An irrigation applied before sowing a crop. After irrigation the land is ploughed and immediately sown.
PATHA.	A wooden beam drawn over the land to produce a tilth.
PHAORA.	A tool for digging used in the manner of an adze.
PUKKA.	Well formed; applied to a road=metalled, to a well refers to one built of masonry.
PYAZI.	Asphodelus fistulosus, Linn.
RABI.	As applied to crops refers to a crop grown during the cold weather.
RAYAT.	A tenant.
REH.	The salt efflorescence which appears on the surface of alkali lands.
RUI.	Cotton lint.
RUPEE.	A coin=1s. 4d. under pre-war rates of exchange.
SAL.	Shorea robusta, Gaertn.
SEER.	$\frac{1}{40}$ maund; roughly two pounds. (or 40 seers = 1 maund)
SHISHAM.	Dalbergia sisoo, Roxb.
TAKKAVI.	A loan made by Government for a specific purpose. Takkavi loans are freely given in years of famine for building wells, purchase of seed, etc.
USAR.	Barren; usar soils are barren soils whether the cause be mechanica or chemical. Reh soils are, therefore, a particular type of usar.
ZEMINDAR.	A landholder.

INDEX

ERRATA

CHAPTER IV., page 24, line 10, *for* "question" *read* "questions."

CHAPTER V., page 32, line 23, *for* "village" *read* "villages."